4 Generating Resources

Generating units in EPA Base Case 2000 include currently operating units, planned-committed units and potential units. Units that are currently operational are termed existing units. Units that are not currently operating but have either broken ground (initiated construction) or secured financing are termed planned-committed. Potential units refer to new generating options included in EPA Base Case 2000 and used by IPM for capacity projections.

This chapter is organized into six sections. Section 4.1 provides background information on the National Electric Data System (NEEDS), the database which serves as the repository for information on existing and planned-committed units that are modeled in the EPA Base Case 2000. Detailed information on the three categories of non-nuclear generating units modeled in EPA Base Case 2000 is presented in Sections 4.2 (existing units), 4.3 (planned-committed units), and 4.4 (potential units). Section 4.5 describes the handling of existing and potential nuclear units in EPA Base Case 2000. Section 4.6 discusses the repowering options provided to coal and oil/gas steam generating units under the base case.

4.1 National Electric Energy Data System (NEEDS)

EPA Base Case 2000 uses the NEEDS database as its source for data on all currently operating and planned-committed units. The current version of NEEDS, NEEDS 2000, is an update of the 1998 version of NEEDS, NEEDS 1998, used in the EPA Winter 1998 Base Case. NEEDS 2000 contains unit-level information and describes the unit's location (model region, state and county), capacity, plant type, pollution controls equipment for SO_2, NO_x and particulate matter, boiler configurations, mercury emission modification factors (EMF), and SO_2 and NO_x emission rates. Table 4.1 below summarizes the sources used in developing data on existing units in NEEDS 2000. The data sources for planned-committed units in NEEDS are discussed below in Section 4.3.

Table 4.1. Data Sources for NEEDS 2000

Data Source	Data Source Documentation
DOE's Form EIA-860a	DOE's Form EIA-860a is an annual survey of utility power plants at the generator level. It contains data such as summer, winter and nameplate capacity, location (state and county), status, prime mover, primary energy source, in-service year, and a plant-level cogenerator flag.
DOE's Form EIA-860b	DOE's Form EIA-860b is an annual survey of non-utility power plants at the generator level. It contains data such as nameplate capacity, location (state, city and zip code), status, on-line year, prime mover, generation, electricity consumed onsite, net useful thermal energy, and primary fuel.
DOE's Form EIA-767	DOE's Form EIA-767 is an annual survey, "Steam-Electric Plant Operation and Design Report", that contains data for utility nuclear and fossil fuel steam boilers such as fuel quantity and quality; boiler identification, location, status, and design information; and post-combustion NO_x control, FGD scrubber and particulate collector device information. Note that boilers in plants with less than 10 MW do not report all data elements. The relationship between boilers and generators is also provided, along with generator-level generation and nameplate capacity. Note that boilers and generators are not necessarily in a one-to-one correspondence.

DOE's Form EIA-759	DOE's Form EIA-759 has two surveys: annual and monthly. The annual survey was used for the EPA Base Case 2000. It contains utility plant-level data based on prime mover and fuel type, such as net generation and on-line year.
NERC Electricity Supply and Demand (ES&D) database	The NERC ES&D is released annually. It contains generator-level information such as summer, winter and nameplate capacity, state, NERC region and sub-region, status, primary fuel and on-line year.
EPA's CEMS 2000 Second Quarter Values	The CEMS (Continuous Emission Monitoring System) database is updated quarterly. It contains boiler-level information such as primary fuel, heat input, SO_2 and NO_x controls, and SO_2, NO_x and CO_2 emissions.
EPA's Information Collection Request (ICR) database	This database has boiler-level information such as boiler firing and bottom types, and SO_2, NO_x and particulate matter controls.
NEEDS 1998	NEEDS 1998 developed by US EPA for the EPA Winter 1998 Base Case. NEEDS 2000 is an update to NEEDS 1998.

4.2 Existing Units

EPA Base Case 2000 models existing units based on information contained in NEEDS. The sections below describe the specific data sources and procedures followed in determining the population, capacity, plant location, unit configuration, model plant aggregation, and cost and performance characteristics of the existing non-nuclear units represented in the base case. Key features of the base case representation of these units are also presented.

4.2.1 Population of Currently Operating Units

The population of currently operating units was taken primarily from 1998 EIA 860a, 1998 EIA 860b, 1998 EIA 767 and NEEDS 1998. A number of rules were used to screen the various data sources. These rules helped to ensure data consistency, but also made the population data adaptable for use in IPM. Table 4.2 below summarizes the rules used in populating NEEDS 2000.

Table 4.2. Rules Used in Populating NEEDS 2000

Scope	Rule in NEEDS 2000
Geographic	• Excluded units in Alaska or Hawaii
Capacity	• Excluded units with reported nameplate, summer and winter capacity of zero
Status	• Excluded units on long-term scheduled maintenance or units with forced outages for greater than three months or retired (i.e. units with status codes "OS" or "RE" in EIA Forms) • Excluded five units with status standby or cold standby that no longer reported emissions to the Acid Rain or NO_x Budget Programs • Status of boiler(s) and associated generator(s) were taken into account for determining operation status
Planned or Future Units	• Included planned units that had broken ground or secured financing and were expected to be online by 2005
Firm/Non-firm Electric Sales	• Excluded non-utility onsite generators that do not produce electricity for sale to the grid • Excluded all mobile and distributed generators

As with previous versions of the database, NEEDS 2000 includes steam units at the boiler level and non-steam units at the generator level. A unit in NEEDS 2000, therefore, refers to a boiler in the case of a steam unit and a generator in the case of a non-steam unit. Table 4.3 below provides a summary of the population statistic through 1998 of currently operating units included in NEEDS 2000.

Table 4.3. Summary of Population (through 1998) in NEEDS 2000

Plant Type	Number of Units	Capacity (MW)
Biomass	112	1,494
Coal Steam	1306	305,224
Combined Cycle	649	37,404
Fossil Waste	7	406
Fuel Cell	2	0.4
Geothermal	195	2,666
Hydro	3,893	89,709
IGCC	3	612
Landfill Gas	7	91
Non-Fossil Waste	115	2,418
Nuclear	103	95,556
O/G Steam	884	133,928
Other	1	13
Pumped Storage	139	22,553
Solar	21	325
Turbine	4,618	63,419
Wind	89	1,605
Total	12,144	757,423

4.2.2 Capacity

To the extent possible, the EPA Base Case 2000 uses net summer dependable capacity[1] in NEEDS 2000. Table 4.4 summarizes the hierarchy of primary data sources used in compiling capacity data for NEEDS 2000.

Table 4.4. Hierarchy of Data Sources for Capacity in NEEDS 2000
(Presented in Order of Hierarchy)

Utility Units	Non-Utility Units
NEEDS 1998	NEEDS 1998
1998 EIA 860a Summer Capacity	1998 EIA 860a Summer Capacity
NERC ES&D 1999 Summer Capacity	NERC ES&D 1999 Summer Capacity
1997 EIA 860 Summer Capacity	1997 EIA 860 Summer Capacity
1998 EIA 860a Winter Capacity	1998 EIA 860a Winter Capacity
NERC ES&D 1999 Winter Capacity	NERC ES&D 1999 Winter Capacity
1997 EIA 860 Winter Capacity	1997 EIA 860 Winter Capacity
1998 EIA 860a Nameplate Capacity	1998 EIA 860b Nameplate Capacity
1997 EIA 860 Nameplate Capacity	If capacity is zero; do not include unit
If capacity is zero; do not include unit	

As noted earlier, for steam units NEEDS 2000 includes boiler level data, while for non-steam units NEEDS 2000 contains generator level data. Capacity data in NERC and EIA data sources are generator specific

[1]As used here, net summer dependable capacity is the net capability of a generating unit in megawatts (MW) for daily planning and operation purposes during the summer peak season, after accounting for station or auxiliary services.

and not specified for the boiler. The development of boiler capacity for steam in NEEDS 2000, therefore, required an algorithm for parsing generator level capacity to the boiler level.

The capacity-parsing algorithm used for steam units in NEEDS 2000 took into account boiler-generator mapping. Fossil steam and nuclear steam electric units have boilers attached to generators that produce electricity. There are generally four types of links between boilers and generators: one boiler to one generator, one boiler to many generators, many boilers to one generator and many boilers to many generators.

The capacity-parsing algorithm used for steam units in NEEDS utilized steam flow data with the boiler-generator mapping. Under EIA 767, steam units report the maximum steam flow from the boiler to the generator. There is, however, no further data on the steam flow of each boiler-generator link. Instead, EIA 767 contains only the maximum steam flow for each boiler. Table 4.5 summarizes the algorithm used for parsing capacity with data on maximum steam flow and boiler-generator mapping. In Table 4.5 MF_{Bi} refers to the maximum steam flow of boiler *i* and MW_{Gi} refers to the capacity of generator *i*. The algorithm uses the available data to derive the capacity of a boiler, referred to as MW_{Bi} in the Table 4.5.

Table 4.5. Capacity-Parsing Algorithm for Steam Units in NEEDS 2000

	Type of Boiler-Generator Link			
For Boiler B_1 to B_N linked to Generators G_1 to G_N	One-to-One	One-to-Many	Many-to-One	Many-to-Many
	$MW_{Bi} = MW_{Gi}$	$MW_{Bi} = \sum_i MW_{Gi}$	$MW_{Bi} = (MF_{Bi} / \sum_i MF_{Bi}) * MW_{Gi}$	$MW_{Bi} = (MF_{Bi} / \sum_i MF_{Bi}) * \sum_i MW_{Gi}$

Since EPA Base Case 2000 uses firm electric demand, NEEDS 2000 only includes firm capacity[2] to be consistent with demand. This affects onsite generators that produce electricity both for sale to the grid and for onsite consumption. For such units, only the firm capacity that the generator sells to the grid is included in NEEDS 2000.

However, there is no reported measure of firm or grid-sales capacity. Data from 1998 was used to estimate firm capacity for onsite generators. The share of net sales to utilities (which serve as a proxy for the grid) to total generation from the onsite generator can be used to derive a capacity adjustment factor for estimating the proportion of firm capacity relative to total capacity for onsite generators.

The EPA Base Case 2000 includes cogeneration units, i.e., units that simultaneously produce steam and electricity for sales. Since the EPA Base Case 2000 does not model steam markets, the net heat rate chargeable to power is used to characterize cogeneration. The net heat rate chargeable to power is a measure of the heat input required for electric production after accounting for steam sales. Through the net heat rate chargeable to power, the EPA Base Case 2000 captures only the fuel and emission components involved in the electric generation of cogeneration units.

[2] As used here, "firm electric demand" is grid-connected demand that is under contract to be met unless an emergency condition arises. "Firm capacity" is grid-connected capacity that is committed by contract to meeting demand except in the event of an emergency condition.

4.2.3 Plant Location

NEEDS 2000 uses State, County and model region data to represent the physical location of a plant.

State and County

NEEDS 2000 used the state and county location for steam boilers reported in 1998 EIA 767. For utility and non-utility generators, the state and county location reported in 1998 EIA 860 was used. When the county was not specified, the five-digit zip code and/or state and city was used to obtain county location.

Model Region

For each unit the associated model region was derived based on NERC regions and sub-regions reported in 1999 NERC ES&D for that unit. For units with no NERC sub-region data, NERC region and state were used to derive associated model regions. For units with no NERC region data, state and county were used to derive associated model regions. Table 3.1 in Chapter 3 provides a summary of the mapping between NERC regions and sub-regions with the model regions in EPA Base Case 2000.

4.2.4 Online and Retirement Year

The EPA Base Case 2000 uses online year to capture when the unit entered service. NEEDS includes online years for all units in the database. In NEEDS 2000, online years for boilers, utility and non-utility generators were derived from reported in-service date in 1998 EIA 767, 1998 EIA 860a and 860b respectively.

The EPA Base Case 2000 does not include any assumption about the retirement year for generating units other than nuclear. For nuclear units, retirement dates are contained in NEEDS only to support the modeling of re-licensing and lifetime extensions. (See Section 4.5 for a fuller discussion of this.) EPA Base Case 2000 does, however, provide economic retirement options to coal, oil and gas steam, combined cycle, combustion turbines, and nuclear units. This means that these units may elect to retire if it is economical to do so. In IPM, an early retired plant ceases to incur FOM and VOM costs. However, retired units do meet capital cost obligations for retrofits if the model projected a retrofit on the unit prior to retirement.

4.2.5 Unit Configuration

Unit configuration refers to the physical specification of a unit's design. Unit configuration in EPA Base Case 2000 drives model plant aggregation, modeling of pollution control options and mercury emission modification factors. NEEDS 2000 contains information on the firing and bottom type of all coal steam boilers in the database. NEEDS 2000 also contains information on installed pollution controls for NO_x, SO_2 and particulate matter on all units in the database. Table 4.6 describes the data sources used in developing unit configuration in NEEDS 2000.

Table 4.6. Data Sources for Unit Configuration in NEEDS 2000

Unit Component	Primary Data Source	Secondary Data Source	Default
Firing Type	1998 EIA 767	CEMS 2000 Quarterly Value	—
Bottom Type	1998 EIA 767	CEMS 2000 Quarterly Value	• If firing is FBC, then dry • If firing is cyclone, then wet • If firing is wall, then dry
SO_2 Pollution Control	EPA's 1999 Information Collection Request (ICR)	• 1998 EIA 767 • CEMS 2000 Second Quarter	No control
NO_x Pollution Control	EPA's 1999 Information Collection Request (ICR)	• 1998 EIA 767 • CEMS 2000 Second Quarter • Press Releases	No control
Particulate Matter Control	EPA's 1999 Information Collection Request (ICR)	1998 EIA 767	No control

4.2.6 Model Plant Aggregation

Although IPM includes all the electric generating units contained in NEEDS, an aggregation scheme clusters real life units into model plants, and IPM uses only the model plants in the actual modeling. The aggregation scheme serves to reduce the size of the model and makes the model manageable while capturing the essential characteristics of the generating units.

The EPA Base Case 2000 includes an aggregation scheme that clusters real life units into model plants based on similarity in characteristics. The aggregation scheme encompasses a variety of different classification categories. These include location, size, technology, efficiency, fuel choices, unit configuration, emission rates and environmental regulations among others. Units are aggregated together only if they match on all the different categories specified for the aggregation. The categories used for the aggregation scheme in EPA Base Case 2000 are:

- Model Region
- Unit Technology Type
- Fuel Demand Region
- Environmental Regulations
    - NO_x SIP Call Participation
    - State Specific Regulations in CT, MO and TX
- State
    - CT, MO and TX
- Unit Configuration
    - Boiler Type
    - Firing Type
    - SO_2 Pollution Control
    - NO_x Pollution Control
    - Particulate Matter Control
- Emission Rates
    - Low and High NO_x Rate Groups
- Heat Rate
    - Low, Mid and High Efficiency Groups
- Size

- Less than 25 MW, greater than or equal to 25 MW and less than 100 MW, and greater than or equal to 100 MW for coal steam units
- Less than 25 MW and greater than or equal to 25 MW for non-coal fossil units and other non-fossil emitting units

Table 4.7 provides a crosswalk between actual plants and model plants in EPA Base Case 2000. For each plant type, the table shows the number of real plants and the number of model plants representing these real plants in EPA Base Case 2000[3]. A more detailed crosswalk between actual and model plants can be found in Appendix 4.1. This appendix includes tables showing the number of actual units and model plants for each plant type by IPM region, capacity category, heat rate category, and compliance zone. Other tables in the appendix look specifically at existing coal units, showing the number of actual and model plants by coal supply region, burner type, particulate control type, and post-combustion control type. Table 4.7 also enumerates the early retirement options built into EPA Base Case 2000. Tables A4.1.6, A4.1.7, A4.1.10, and A4.1.11 in Appendix 4.1 provide breakdowns of retirement options by IPM region, capacity category, heat rate category, and compliance zone.

[3]For readers interested in the intricacies of Table 4.7, here are several observations: (1) Depending on its capacity and fuel types combusted, an existing coal steam model plant may be provided with multiple scrubber and ACI retrofit options. As a result the total number of model plants representing scrubber and ACI retrofits may exceed the total number of model plants representing existing coal steam units. (See section 5.1 and 5.3 for a detailed description of the sulfur dioxide (scrubber) and mercury (ACI) retrofit options.) (2) The number of model plants in the category "Retrofit Coal to Scrubber+SCR" exceeds the number of "Coal Steam" model plants, because "Retrofit Coal to Scrubber+SCR" includes multiple scrubber options (LSFO, MEL, or LSD) and multiple timing options (1st stage scrubber + 2nd stage SCR, 1st stage SCR + 2nd stage scrubber, or both scrubber and SCR simultaneously). Similar observations apply to the category "Retrofit Coal to Scrubber+SNCR." (3) Since EPA Base Case 2000 assumes that selective catalytic reduction is a retrofit option for existing coal steam units with a capacity of 100 MW or greater, the total number of model plants representing SCR retrofits is smaller than the number of model plants representing existing coal steam units. (See section 5.2 for a detailed description of nitrogen oxide retrofit options.) (4) There are no model plants assigned to represent the two existing fuel cells, because, by convention, existing units with 0 MW capacity (rounded to the unit digit) are not assigned a model plant. The two existing fuel cells have a capacity of 0.4 MW. (5) The total number of model plants representing different types of new units often exceeds the 26 IPM regions and vary from technology to technology for several reasons. First, most technologies have two vintages, which must be represented by separate model plants in each IPM region. Second, some technologies are not available in particular regions (e.g., geothermal is geographically restricted to certain regions, conventional pulverized coal is not provided as an option in CALI). Third, IPM regions with portions in and out of the SIP call jurisdiction (e.g., MANO, MAPP, NENG, SOU, TVA, WUMS) are assigned one additional model plant per vintage for the portions within and outside the SIP call, thereby increasing the total number of model plants representing particular technologies in those IPM regions. Similarly, regions containing Connecticut (NENG), Missouri (MAPP and MANO), or Texas (AZNM, ENTG, and SPSS) along with other states are assigned one additional model plant per vintage to accommodate the state specific regulations in these three states. Table A4.1.8 in the appendix for this chapter gives a breakdown by IPM region of the number of model plants representing the different types of new plants. (6) There are fewer "Combustion Turbine Early Retirement" model plants than existing "Turbine" (CT) model plants and fewer "Combined Cycle Early Retirement" model plants than existing "Combined Cycle" (CC) model plants, because the co-generation subset of the existing CT and CC population is not given the option of early retirement, due to their high efficiency in electricity production. (7) While existing cogen "Coal Steam" plants are also more efficient than regular "Coal," they are provided with the option of early retirement, because environmental regulations are likely to affect coal cogens more than cogen CTs and CCS. As a result the number of "Coal Early Retirement" model plants is the same as the number of existing "Coal Steam" model plants.

Table 4.7. Aggregation Profile for Model Plants As Provided in Set Up of EPA Base Case 2000

Existing Units*		
Plant Type	**Number of Units**	**Number of IPM model Plants**
Coal Steam	1,308	655
Oil/Gas Steam	884	174
Combined Cycle	723	156
Turbine	4,676	227
Integrated Gas Combined Cycle (IGCC)	3	3
Nuclear	103	47
Hydro	3,894	31
Pumped Storage	139	18
Biomass	112	23
Wind	91	8
Fuel Cell	2	0
Solar	21	2
Geothermal	197	2
Landfill Gas	7	3
Fossil Waste	7	6
Non-Fossil Waste	116	30
Total	**12,283**	**1,385**

*IPM plants with total capacity of #0.5 MW were not included in the EPA Base Case 2000

New Units		
Conventional Pulverized Coal	---	76
IGCC	---	76
Combined Cycle	---	78
Combustion Turbine	---	78
Advanced Combustion Turbine	---	78
Advanced Nuclear	---	78
Biomass	---	41
Wind	---	195
Fuel Cells	---	78
Solar Photovoltaics	---	34
Solar Thermal	---	18
Geothermal	---	16
Landfill Gas	---	41
Total	**---**	**887**

Retrofits		
	Number of Units	**Number of IPM model Plants**
Coal To Scrubber Retrofit	---	461
Retrofit Coal to Scrubber+SCR	---	884
Retrofit Coal to Scrubber+SNCR	---	896
Retrofit Coal to Gas Reburn	---	137
Retrofit Coal to Gas Reburn + Scrubber	---	96
Retrofit Coal to Selective Catalytic Reduction (SCR)	---	357
Retrofit Coal to Selective Noncatalytic Reduction (SNCR)	---	617
Retrofit Coal to Activated Carbon Injection (ACI)	---	845
Retrofit Coal to ACI + SCR	---	346
Retrofit Coal to ACI + SNCR	---	647
Retrofit Coal to ACI+Scrubber	---	838
Retrofit Coal to ACI+Scrubber+SCR	---	133
Retrofit Coal to ACI+Scrubber+SNCR	---	135
Retrofit Oil and Gas to SCR	---	186
Retrofit Oil and Gas to SNCR	---	186
Retrofit Nuclear -- 10 year extension at age 30	---	30
Retrofit Nuclear -- 20 year extension at age 40	---	16
Retrofit Nuclear -- 10 and 20 year extensions	---	30
Total	**---**	**6,840**

Repowerings		
Coal to Combined Cycle repowering	---	539
Coal to IGCC repowering	---	539
Oil and Gas to Combined Cycle repowering	---	174
Total	**---**	**1,252**

Early Retirements		
Coal Early Retirement	---	655
Oil and Gas Early Retirement	---	174
Combined Cycle Early Retirement	---	83
Combustion Turbine Early Retirement	---	190
Nuclear Early Retirement	---	47
Total	**---**	**1,149**

Grand Total (Existing + New + Retrofits + Repowerings + Early Retirements): 11,513

4.2.7 Cost and Performance of Existing Units

The EPA Base Case 2000 uses heat rate, emission rates, variable operation and maintenance cost (VOM) and fixed operation and maintenance costs (FOM) to characterize the cost and performance of all existing units in NEEDS 2000. For existing units, EPA Base Case 2000 includes only incremental production costs. The embedded costs of existing units, such as carrying capital charges, are not modeled. The section below contains a discussion of the cost and performance assumptions for existing units used in the EPA Base Case 2000.

Variable Operating and Maintenance Cost (VOM)

VOM represents the non-fuel cost associated with producing a unit of electricity. If the generating unit contains pollution control equipment, VOM includes the cost of operating the control equipment. Table 4.8 below summarizes VOM assumptions used in EPA Base Case 2000.

Table 4.8. VOM Assumptions (1999$) in EPA Base Case 2000

Capacity Type	NO_x Control	Variable O&M (mills/kWh)
Unscrubbed Coal	No NO_x	1.5
	SCR	2.5
	SNCR	2.5
	Gas Reburn	1.5
Scrubbed Coal	No NO_x	2.9
	SCR	3.9
	SNCR	3.9
	Gas Reburn	2.9
Oil/Gas Steam	No NO_x	2.6
	SCR	2.7
	SNCR	3.0
Combined-Cycle	—	1.0
Combustion Turbines	—	1.0
Nuclear	—	2.0

Note: To three significant digits, the VOM for SCR on unscrubbed coal plants is 2.51 mills/kWh, compared to 2.45 mills/kWh for SNCR. On scrubbed coal plants, it is 3.91 mills/kWh for SCR and 3.86 mills/kWh for SNCR.

Fixed Operation and Maintenance Cost (FOM)

FOM represents the annual cost of maintaining a unit. FOM costs are incurred independent of achieved generation levels and signify the fixed cost of operating and maintaining the unit for generation. Table 4.9 summarizes the FOM assumptions used in EPA Base Case 2000. Note that FOM varies by the age of the unit. The values appearing in this table include the cost of maintaining any associated pollution control equipment. The values in Table 4.9 are based on FERC (Federal Energy Regulatory Commission) Form 1 data provided in summary format by EIA.

Table 4.9. FOM Assumptions Used in EPA Base Case 2000

Prime Mover Type	Primary Fuel	NO_x Control	Age of Unit In 1998	FOM (1999$/kW-Yr)
Steam Turbine	Coal Unscrubbed	No NO_x	0 to 10 years	11.7
			10 to 20 years	17.4
			20 to 30 years	21.4
			Greater than 30 years	27.0
		SCR	0 to 10 years	12.2
			10 to 20 years	18.0
			20 to 30 years	22.0
			Greater than 30 years	27.6
		SNCR	0 to 10 years	11.9
			10 to 20 years	17.6
			20 to 30 years	21.6
			Greater than 30 years	27.2
		Gas Reburn	0 to 10 years	12.0
			10 to 20 years	17.7
			20 to 30 years	21.7
			Greater than 30 years	27.3
	Coal Scrubbed	No NO_x	0 to 10 years	23.1
			10 to 20 years	35.6
			20 to 30 years	37.7
			Greater than 30 years	38.0
		SCR	0 to 10 years	23.7
			10 to 20 years	36.2
			20 to 30 years	38.3
			Greater than 30 years	38.5
		SNCR	0 to 10 years	23.3
			10 to 20 years	35.8
			20 to 30 years	37.9
			Greater than 30 years	38.1
		Gas Reburn	0 to 10 years	23.4
			10 to 20 years	35.9
			20 to 30 years	38.0
			Greater than 30 years	38.3
	Oil & Gas	No NO_x	0 to 20 years	10.7
			20 to 30 years	14.7
			Greater than 30 years	16.4
		SCR	0 to 20 years	11.9
			20 to 30 years	15.9
			Greater than 30 years	17.5
		SNCR	0 to 20 years	11.0
			20 to 30 years	15.0
			Greater than 30 years	16.6
Combined Cycle	Oil & Gas	-	0 to 10 years	13.9
			Greater than 10 years	14.9
Gas Turbine	Oil & Gas	-	0 to 10 years	2.8
			10 to 20 years	2.8
			Greater than 20 years	6.2
Hydro	Water	-	0 to 30 years	13.9
			Greater than 30 years	15.5
Pump Storage	Water	-	All years	6.5

Heat Rates
The treatment of heat rates in EPA Base Case 2000 was discussed in Section 3.8.

Lifetimes
Unit lifetime assumptions in EPA Base Case 2000 are detailed in Sections 3.7 and 4.2.4.

SO_2 Rates
Section 3.9.1 contains a detailed discussion of SO_2 rates for existing units.

NO_x Rates
Section 3.9.2 contains a detailed discussion of NO_x rates for existing units.

Mercury Emission Modification Factors (EMF)
Mercury EMF refers to the ratio of mercury emissions (mercury outlet) to the mercury content of the fuel (mercury inlet). Section 5.3.2 contains a detailed discussion of the EMF assumptions in EPA Base Case 2000.

4.3 PLANNED-COMMITTED UNITS

The EPA Base Case 2000 includes all planned-committed units that are likely to come online before 2005. Like existing units, planned-committed units are contained in NEEDS.

4.3.1 Population

In EPA Base Case 2000, a planned-committed unit was included in NEEDS 2000 only if it had broken ground (initiated construction) or secured financing and was committed to be on-line before 2005. The population of planned-committed units in NEEDS 2000 was developed using several data sources:

1. Units locating in WSCC were taken from the new unit database developed by California Energy Commission (CEC) for planned units,
2. Units locating outside the WSCC region were identified using two databases — one developed by Cambridge Energy Research Associates (CERA), the other developed by ICF Consulting, Inc.

NEEDS 2000 does not list the planned-committed units on a unit by unit basis. Rather, all units having similar technologies and located within the same model region are aggregated together as one record. Table 4.10 summarizes the planned-committed unit total capacity in EPA Base Case 2000 by unit technology type and model region.

Table 4.10. Planned-Committed Units in EPA Base Case 2000 by Model Region

IPM Region	Unit Type	Number of Units	Capacity (MW)
AZNM	Combined Cycle	4	1,776
AZNM	Turbine	1	112
CALI	Combined Cycle	4	2,923
CALI	Geothermal	2	59
ECAO	Coal Steam	1	180
ECAO	Hydro	1	80
ECAO	Turbine	16	3,280
ENTG	Combined Cycle	2	699
ERCT	Combined Cycle	25	15,412
ERCT	Turbine	3	640
ERCT	Wind	1	75
FRCC	Turbine	1	167
MACE	Combined Cycle	1	816
MACE	Turbine	1	168
MACW	Combined Cycle	1	700
MACW	Wind	1	10
MANO	Combined Cycle	7	2,998
MANO	Turbine	9	2,586
MAPP	Turbine	1	1
MECS	Turbine	1	100
NENG	Combined Cycle	12	5,234
NWPE	Combined Cycle	2	287
PNW	Combined Cycle	2	719
RMPA	Coal Steam	1	37
RMPA	Combined Cycle	1	265
RMPA	Turbine	1	74
SOU	Combined Cycle	4	2,300
SOU	Turbine	6	3,810
SPPN	Combined Cycle	3	860
SPPN	Turbine	3	5
SPPS	Combined Cycle	5	3,580
SPPS	Turbine	2	320
TVA	Turbine	2	1,155
VACA	Combined Cycle	1	800
VACA	Turbine	7	2,111
WUMS	Turbine	4	366
Total		139	54,704

4.3.2 Capacity

The capacity of planned-committed units in NEEDS 2000 was obtained from the capacity reported in the databases noted above in Section 4.3.1. The CEC database directly provided the capacity data for units locating in WSCC. The capacity of units locating outside the WSCC region was calculated using the minimum matching capacity across the CERA and ICF databases for each state and technology type.

4.3.3 State and Model Region
State location data for the planned-committed units in NEEDS 2000 came from the three databases noted in Section 4.3.1. State information was used to assign planned-committed units to their respective model regions.

4.3.4 Online and Retirement Year
As noted above, the population of planned-committed units in NEEDS 2000 includes only those units that are likely to come on-line before 2005. All planned-committed units were given a default online year of 2005 since this is the first analysis year in EPA Base Case 2000. The assumptions in EPA Base Case 2000 do not include a lifetime for planned-committed units.

4.3.5 Unit Configuration and Cost-and-Performance
All planned-committed units in NEEDS 2000 take on the cost-and-performance and unit configuration characteristics of potential units that are available in 2005. The assumptions for potential units in EPA Base Case 2000 are discussed in full under Section 4.4.

4.4 POTENTIAL UNITS
The EPA Base Case 2000 includes options for developing a variety of potential units that may come online at a future date. Defined by region, technology and the year available, potential units with an initial capacity of 0 MW are inputs into IPM. When the model is run, the capacity of certain potential units is raised from zero to meet demand and other system and operating constraints. This results in the model's projection of new capacity.

Table 4.7 and several tables in Appendix 4.1 give a breakdown of the number of potential units provided in EPA Base Case 2000. Table 4.7 shows the number of potential (new) units at set-up by plant type. Tables A4.1.8 and A4.1.9 in Appendix 4.1 give a breakdown of potential (new) units by IPM region and compliance zone. This section describes the cost and performance assumptions for potential non-nuclear units used in the EPA Base Case 2000. Potential nuclear units are treated below in Section 4.5.2.

4.4.1 Methodology
Cost and performance assumptions for potential units in EPA Base Case 2000 have been based primarily on data from Annual Energy Outlook (AEO) 2000 published by the Energy Information Administration. AEO provides a comprehensive data source for these assumptions and is widely used in analyses of power markets.

The engineering and procurement cost of developing and building a new plant is captured through the capital cost. AEO 2000 reports overnight capital cost, which does not include interest during construction (IDC). The EPA Base Case 2000 uses overnight capital cost from AEO and includes IDC in developing the total capital cost for new units. Calculation of IDC is based on the construction profile and the discount rate. Details on the discount rates used in the EPA Base Case 2000 are contained in Chapter 7 under financial assumptions. The total capital cost includes expenditures on pollution control equipment that new units are assumed to install to satisfy air regulatory requirements.

Once a unit is built, the maintenance and operation cost of a new unit is characterized by the fixed operation and maintenance cost and the variable operation and maintenance cost. Performance assumptions for the new unit are characterized by the heat rate, availability and emission rates. The emission characteristics for new units in the EPA Base Case 2000 are presented in Section 3.9.5.

The capital costs reported in AEO 2000 are generic. Before being used for modeling, they must be converted to region specific costs. Capital costs in EPA Base Case 2000 are made region specific through the application of regional adjustment factors that capture regional differences for labor, material and construction costs. The regional factors are based on AEO 2000 and differ for conventional and renewable resource generating technologies. The regional factors used in EPA Base Case 2000 are provided in Table 4.11 below.

Table 4.11. Regional Cost Adjustment Factors for Conventional and Renewable Generating Technologies

Model Region Name	Region Code	Regional Factor: Renewables	Regional Factor: Conventional
Michigan Electric Coordination System	MECS	1.01	1.01
East Central Area Reliability Coordination Agreement–South	ECAO	1.01	1.01
Electric Reliability Council of Texas	ERCT	1.00	0.99
Mid-Atlantic Area Council - East	MACE	1.00	1.00
Mid-Atlantic Area Council - West	MACW	1.00	1.00
Mid-Atlantic Area Council - South	MACS	1.00	1.00
Wisconsin-Upper Michigan	WUMS	1.01	1.01
Mid-America Interconnected Network - South	MANO	1.01	1.01
Mid-Continent Area Power Pool	MAPP	1.01	1.01
Upstate New York	UPNY	1.12	1.14
Downstate New York	DSNY	1.12	1.14
New York City	NYC	1.12	1.14
Long Island Lighting Company	LILC	1.12	1.14
New England Power Pool	NENG	1.12	1.14
Florida Reliability Coordinating Council	FRCC	0.86	0.85
Virginia-Carolinas	VACA	0.91	0.90
Tennessee Valley Authority	TVA	0.91	0.90
Southern Company	SOU	0.91	0.90
Entergy	ENTG	1.02	1.02
Southwest Power Pool - North	SPPN	1.02	1.02
Southwest Power Pool - South	SPPS	1.02	1.02
Western Systems Coordinating Council – California	CALI	1.02	1.10
Western Systems Coordinating Council - Pacific Northwest	PNW	1.02	1.03
Western Systems Coordinating Council – AZNMSNV	AZNM	1.04	1.04
Western Systems Coordinating Council - Rocky Mountain Power Area	RMPA	1.04	1.04
Western Systems Coordinating Council - Northwest Power Pool East	NWPE	1.02	1.03

4.4.2 Cost and Performance for Potential Conventional Units

The EPA Base Case 2000 includes pulverized coal, Integrated Gasification Combined Cycle (IGCC), Combined Cycle (CC), Combustion Turbine (CT), Advanced CT, and Advanced Nuclear as potential conventional units. Table 4.12 summarizes the assumptions in EPA Base Case 2000 for these potential units. The cost and performance assumptions are based on the size (i.e., electrical generating capacity in MW) shown in the table. The total new capacity that can come online for these technologies is not restricted in the EPA Base Case 2000. Lead time represents the construction time needed for a unit to come online, and availability describes the percent of hours in a year that the unit can operate once it has come online. Vintage groupings capture the cost and performance improvements resulting from technological change and learning-by-doing.

Table 4.12. Performance and Unit Cost Assumptions for Potential (New) Capacity from Conventional Fossil and Nuclear Technologies in EPA Base Case 2000

	Conventional Pulverized Coal	Integrated Gasification Combined Cycle	Combined Cycle	Advanced Combustion Turbine	Combustion Turbine	Advanced Nuclear
Size (MW)	400	428	400	120	160	600
First Year Available	2005	2005	2005	2005	2005	2005
Lead Time(years)	4	4	3	2	2	4
Vintage #1 (years covered)	2005-2009	2005-2009	2005-2009	2005-2009	2005-2009	2005-2009
Vintage #2 (years covered)	2010 & after	2010 & after	2010 & after	2010 & after	2010 & after	2010-2014
Vintage #3 (years covered)	N/A	N/A	N/A	N/A	N/A	2015 & after
Availability	85%	87.7%	90.4%	92.3%	92.3%	90.7%
Vintage #1						
Heat Rate (Btu/kWh)	9,253	7,469	6,562	8,567	11,033	10,400
Capital ($/kW)	1,321	1,427	590	438	388	2,465
Fixed O&M ($/kW/yr)	20.08	32.12	12.74	8.93	6.08	50.97
Variable O&M ($/MWh)	3.87	1.10	1.10	1.00	1.00	2.03
Vintage #2						
Heat Rate (Btu/kWh)	9,087	6,968	6,350	8,000	10,600	10,400
Capital ($/kW)	1,305	1,393	563	394	348	2,402
Fixed O&M ($/kW/yr)	20.08	32.12	12.74	8.93	6.08	50.97
Variable O&M ($/MWh)	3.87	1.10	1.10	1.00	1.00	2.03
Vintage #3						
Heat Rate (Btu/kWh)	—	—	—	—	—	10,400
Capital ($/kW)	—	—	—	—	—	2,276
Fixed O&M ($/kW/yr)	—	—	—	—	—	50.97
Variable O&M ($/MWh)	—	—	—	—	—	2.03

Notes: (1) Capital cost represents overnight capital cost plus interest during construction. (2) Variable O&M costs were adjusted to be consistent with VOM cost assumptions for existing units. Fixed O&M was adjusted to preserve the new unit's total O&M.

4.4.3 Cost and Performance for Potential Renewable Generating and Non-Conventional Technologies

Renewable generating technologies included as potential units in the EPA Base Case 2000 are biomass gasification combined cycle (BGCC), wind, solar photovoltaic, solar thermal, geothermal and landfill gas. An option for new fuel cell plants has also been included in EPA Base Case 2000. Table 4.13 summarizes the assumptions in EPA Base Case 2000 for these potential units. The size (MW) presented in Table 4.13 represents the capacity on which unit cost estimates were developed and does not indicate the total potential for any technology. Except for landfill gas[4], the cost and performance assumptions were adapted from AEO 2000. Due to the distinctive nature of generation from renewable resources, some of the values shown in Table 4.13 are averages that do not fully reflect the cost and performance implementation of these units in EPA Base Case 2000. A fuller description of these distinctive cost and performance implementations is given below.

Generation Profiles for Solar and Wind Units

Since wind and solar electric generation units rely on intermittent resources, EPA Base Case 2000 includes generation profile assumptions for these two technologies. Each eligible IPM region is provided with a distinct set of winter and summer generation profiles for wind, solar thermal, and solar photovoltaic plants. The generation profiles, which specify hourly generation patterns for a representative day in winter and summer, define the dispatch of these units. As discussed below, the generation profiles are also used to define their reserve margin contributions. The wind and solar generation profiles are based on AEO 2000. A representative generation profile for wind, solar thermal, and solar photovoltaic is reproduced in Appendix 4.2. The remaining renewable resource generation technologies dispatch on an economic basis subject to their availability constraint and, as discussed below, their resource potential.

[4]The cost and performance assumptions for landfill gas were obtained from *EPlus Users Manual 1997*; Turning Liability into Asset: A Landfill Gas to Energy Project Development Handbook, EPA 1996, and consultation with internal combustion engine manufacturers.

Table 4.13. Performance and Unit Cost Assumptions for New Capacity from Renewable and Non-Conventional Technologies in EPA Base Case 2000

	Biomass Gasification Combined Cycle	Wind	Fuel Cells	Solar Photovoltaic	Solar Thermal	Geothermal	Landfill Gas
Size (MW)	100	50	10	5	100	100	100
First Year Available	2010	2005	2005	2005	2005	2005	2005
Lead Time (years)	4	3	2	2	3	4	1
Vintage #1 (years covered)	2010-2030	2005-2030	2005-2014	2005-2030	2005-2030	2005-2030	2005-2030
Vintage #2 (years covered)	--	--	2015-2030	--	--	--	--
Availability	87.7%	90%	90.7%	90%	90%	87%	85%
Generation capability	Economic Dispatch	Generation Profile	Economic Dispatch	Generation Profile	Generation Profile	Economic Dispatch	Economic Dispatch
Vintage #1							
Heat Rate (Btu/kWh)	8,219	0	5,574	0	0	32,391	10,000
Capital ($/kW)	1,490	1,031-2,625	2,175	2,576	3,187	1,846-6,174	1,299
Fixed O&M ($/kW/yr)	44.81	26.41	15.00	9.97	47.40	62.40-210.50[3]	78.58
Variable O&M ($/MWh)	5.34	0.00	2.06	0.00	0.00	0.00	10.48
Vintage #2							
Heat Rate (Btu/kWh)	--	--	5,361	--	--	--	--
Capital ($/kW)	--	--	1,566	--	--	--	--
Fixed O&M ($/kW/yr)	--	--	15.00	--	--	--	--
Variable O&M ($/MWh)	--	--	2.06	--	--	--	--

Notes: Capital costs for wind plants vary by wind class and cost class; Capital and fixed O&M costs for geothermal plants are site specific.

Additional Cost Considerations

Wind Plants: Wind resources are conventionally categorized into power classes, ranging from class 1 (the lowest) to class 7 (the highest). Each class represents a range of mean wind power density (in units of watts per square meter). Areas designated class 3 or higher are generally suitable for commercial wind turbine applications. Only potential wind capacity in wind classes 6, 5 and 4 have been included in the EPA Base Case 2000. (Class 7 areas are primarily found only in Alaska and Hawaii which are not included in EPA Base Case 2000. Exposed ridge crests and mountain summits in the lower 48 states which experience class 7 wind conditions are generally unsuitable for wind energy development due to icing and inaccessibility caused by poor weather and snow depths during winter months.)

The capital costs for new wind plants in Table 4.13 include assumptions on terrain degradation and grid interconnection cost. Terrain degradation refers to the notion that as new wind capacity is added, it will be necessary to move towards terrain that is more difficult to develop. Additionally, wind plants are often located more than average distances away from the transmission grid. Consequently new wind plants would need to build transmission lines to the grid. The wind cost adders for terrain degradation and grid interconnection were adapted from AEO 2000 data.[5]

In the EPA Base Case 2000 three cost classes were developed to capture cost impacts of terrain degradation and grid interconnection. Class 1 has the lowest terrain and grid interconnect costs and Class 3 has the highest. The three cost classes and the corresponding cost assumptions are presented in Table 4.14 below. To capture the cost impact of terrain degradation, the base capital cost of $997/kW (1999 $) for new wind plants was scaled using the cost adjustment factor. A separate cost adjustment factor, applicable across all model regions, was developed for each cost class. The three terrain degradation cost adjustment factors are shown in the last row of Table 4.14.

The $/kW adders (shown in the body of Table 4.14) represent the interconnection cost and vary by region and wind class. These interconnection costs were based on AEO 2000 estimates of available land area by wind class.[6] In some regions, interconnection costs do not change from one cost class to another because the average distance to the grid may not change while the terrain degradation cost adjustment factor changes.

[5] Petersik, Thomas, "Modeling the Costs of US Wind Supply," Energy Information Administration, Issues in Midterm Analysis and Forecasting 1999.
[6] Ibid.

Table 4.14. Capital Cost Interconnect Adders and Terrain Degradation Adjustment Factors for New Wind Plants (1999$/kw)

Interconnect Adders		Cost Class		
Model Region	Wind Class	1	2	3
AZNM	4	6.5	6.5	19.4
	5	6.5	6.5	26.3
	6	6.5	6.5	21.4
CALI	4	11.1	11.1	29.0
	5	11.1	11.1	31.2
	6	11.1	11.1	23.0
DSNY	4	9.2	9.2	29.2
	5	18.5	18.5	72.2
ECAO	4	8.3	8.3	28.2
	5	8.3	8.3	32.7
ENTG	4	10.0	10.0	29.6
ERCT	4	8.4	20.8	32.0
MACE	4	11.3	11.3	36.5
MACS	4	11.3	11.3	36.5
MACW	4	11.3	11.3	36.5
MAPP	4	8.0	8.0	28.6
	5	8.0	8.0	28.8
MECS	4	8.3	8.3	28.2
	5	8.3	8.3	32.7
NENG	4	8.9	8.9	20.4
	5	8.9	8.9	31.8
	6	8.9	8.9	39.7
NWPE	4	8.8	8.8	30.9
	5	8.8	8.8	30.3
	6	8.8	8.8	31.4
PNW	4	8.8	8.8	30.9
	5	8.8	8.8	30.3
	6	8.8	8.8	31.4
RMPA	4	6.5	6.5	19.4
	5	6.5	6.5	26.3
	6	6.5	6.5	21.4
SOU	4	10.3	10.7	61.0
	5	10.3	10.7	61.0
	6	10.3	10.7	61.0
SPPN	4	10.0	10.0	29.6
SPPS	4	10.0	10.0	29.6
TVA	4	10.3	10.7	61.0
	5	10.3	10.7	61.0
	6	10.3	10.7	61.0
UPNY	4	9.2	9.2	29.2
	5	18.5	18.5	72.2
VACA	4	10.3	10.7	61.0
	5	10.3	10.7	61.0
	6	10.3	10.7	61.0
Terrain Cost Adjustment Factors		1.0	1.8	2.5

Geothermal Generation: EPA Base Case 2000 does not contain a single capital cost, but multiple geographically-dependent capital costs for geothermal generation. The assumptions for geothermal were developed using AEO 2000 cost and performance estimates for 51 known sites. Both dual flash and binary cycle technologies[7] were represented. In EPA Base Case 2000 the 51 sites were collapsed into 14 different options based on geographic location and cost and performance characteristics of geothermal sites in each of the five eligible IPM regions where geothermal generation opportunities exist. A complete listing of the geothermal options implemented in EPA Base Case 2000 is included in Appendix 4.3 .

Resource Potential

In EPA Base Case 2000 limitations on the supply of renewable resources are modeled through capacity bounds. For intermittent resources (i.e., wind and solar), generation profiles also represent constraints on resource availability. The constraint assumptions for applicable technologies are discussed below.

Landfill Gas: Estimates of potential electric capacity from landfill gas are based on existing landfill sites. Inventory data of existing landfill sites were taken from US EPA Landfill Methane Outreach Program (LMOP)[8] state profiles and supplemented with data from 1999 Bio-Cycle Nationwide Survey[9] where necessary. Table 4.15 summarizes potential electric capacity from landfill gas used in EPA Base Case 2000. The cost and performance assumptions for adding new landfill capacity were presented earlier in Table 4.13. The values shown below in Table 4.15 represent an upper bound on the amount of new landfill capacity that can be added in each of the indicated model regions.

Table 4.15. Assumptions on Potential Electric Capacity from Landfill Gas

Region	Capacity (MW)
AZNM	112
CALI	528
DSNY	45
ECAO	492
ENTG	93
ERCT	344
FRCC	144
MACE	93
MACS	78
MACW	118
MANO	442
MAPP	120
MECS	180
NENG	75
NWPE	112
PNW	128
RMPA	112

[7] In dual flash systems, high temperature water (above 400/F) is sprayed into a tank held at a much lower pressure than the fluid. This causes some of the fluid to "flash," i.e., rapidly vaporize to steam. The steam is used to drive a turbine, which, in turn, drives a generator. In the binary cycle technology, moderate temperature water (less than 400/F) vaporizes a secondary, working fluid which drives a turbine and generator. Due to its use of more plentiful, lower temperature geothermal fluids, these systems tend to be most cost effective and are expected to be the most prevalent future geothermal technology.
[8] "Landfill Gas-to-Energy Project Opportunities, Landfill Profiles for the State of __," US EPA, January 1999. For each state, there is a separate report bearing the same title.
[9] "Bio-Cycle Journal of Composting and Recycling," Vol. 40, No. 4, 11th Annual Bio-cycle Nationwide.

SOU	210
SPPN	58
SPPS	66
TVA	110
UPNY	66
VACA	332
WUMS	72
Grand Total	4,130

Geothermal: Assumptions in EPA Base Case 2000 on potential geothermal capacity were developed using AEO 2000 data. The maximum geothermal electric capacity achievable in EPA Base Case 2000 are described in Table 4.16 below.

Table 4.16. Assumptions on Potential Geothermal Electric Capacity

Region	Capacity (MW)
AZNM	1,195
CALI	8,344
NWPE	2,161
PNW	3,800
RMPA	1,675
Grand Total	17,175

Wind: Assumptions on potential wind capacity in EPA Base Case 2000 were developed using wind speed data from AEO 2000. In every eligible IPM model region in EPA Base Case 2000 there is a specific capacity limit for each wind class and each cost class. These are shown in Table 4.17 below.

Table 4.17a. Assumptions on Potential Wind Capacity by Wind Class (MW)

	Wind Class		
Model Region	4	5	6
AZNM	87,050	700	11,600
CALI	7,700	4,400	8,000
DSNY	1,550	300	
ECAO	1,750	200	
ENTG	239,900		
ERCT	9,900		
MACE	3,067		
MACS	3,067		
MACW	3,067		
MAPP	1,315,300	101,800	
MECS	1,750	200	
NENG	5,100	3,601	200
NWPE	93,450	24,450	35,150
PNW	93,450	24,450	35,150
RMPA	87,050	700	11,600
SOU	367	217	205
SPPN	239,900		
SPPS	239,900		
TVA	367	217	205
UPNY	1,550	300	
VACA	367	217	205
Grand Total	2,435,602	161,752	102,315

Table 4.17b Assumptions on Potential Wind Capacity by Cost Class (MW)

	Cost Class		
Model Region	1	2	3
AZNM	2,000	5,950	91,400
CALI	2,401	1,400	16,299
DSNY	150	501	1,200
ECAO	200	400	1,350
ENTG	1,200	9,600	229,500
ERCT	1,500	3,300	5,100
MACE	300	600	2,167
MACS	300	600	2,167
MACW	300	600	2,167
MAPP	7,100	56,700	1,353,300
MECS	200	400	1,350
NENG	900	2,701	5,300
NWPE	3,850	10,900	138,300
PNW	3,850	10,900	138,300
RMPA	2,000	5,950	91,400
SOU	67	600	121
SPPN	800	9,600	229,500
SPPS	800	9,600	229,500
TVA	67	600	121
UPNY	150	501	1,200
VACA	67	600	121
Grand Total	27,802	132,003	2,539,863

Solar: Similar to AEO 2000, no explicit constraint limit is placed on solar electric capacity in EPA Base Case 2000. However, since solar thermal is only feasible in areas with sufficient direct insolation, the EPA Base Case 2000 includes the assumption that new solar thermal plants can only be built west of the Mississippi. Solar photovoltaic is not limited to specific parts of the country.

Reserve Margin Contribution and Generation Profile

The EPA Base Case 2000 uses reserve margins, discussed in detail in Section 3.6, to model reliability. Each region has a reserve margin requirement which is used to determine the total capacity needed to meet peak demand. The ability of a unit to assist a region in meeting its reliability requirements is modeled through the unit's contribution to reserve margin. If the unit has 100 percent contribution towards reserve margin, then the entire capacity of the unit is counted towards meeting the region's reserve margin requirement. However, if any unit has less than 100 percent contribution towards reserve margin, then only the designated share of the unit's capacity counts towards the reserve margin requirement.

All units except those that depend on intermittent resources have 100% contributions toward reserve margin. This means that all renewable resource technologies except wind and solar, have 100 percent contribution towards reserve margin in the EPA Base Case 2000.

For wind and solar units, the contribution towards reserve margins depends on a unit's generation profiles. An algorithm proposed by Michael Milligan and Brian Parson at NREL was used.[10] First, the projected hourly load for 2010 was arranged from highest to lowest. Second, the average generation, derived from the generation profile, for the top 30% of the hours was computed. The resulting value, expressed as a percent of the unit's rated output capacity, was used as the reserve margin contribution for the unit. To maintain internal consistency, the contributions to reserve margin for wind and solar units were calculated using generation profiles used in the EPA Base Case 2000 rather than historic generation data.
Table 4.18 summarizes the average capacity factors (CFs) and contributions to reserve margin for solar units assumed in EPA Base Case 2000. The region-specific summer and winter capacity factors presented in this table are metrics that provide a shorthand depiction of the hourly specific generation profiles for each region. For existing solar units, assumptions on capacity factors and contributions to reserve margins were developed using historical data.

[10] Milligan, Michael and Parsons, Brian, "A Comparison and Case Study of Capacity Credit Algorithms for Intermittent Generators," National Renewable Energy Laboratory (NREL), Presented at Solar 1997, April 1997.

Table 4.18. Reserve Margin Contribution and Average Capacity Factor by Model Region

Model Region	Solar Thermal			Solar Photovoltaic		
	Summer Average CF	Winter Average CF	Reserve Margin Contribution	Summer Average CF	Winter Average CF	Reserve Margin Contribution
AZNM	36%	27%	44%	24%	24%	31%
CALI	43%	29%	54%	25%	21%	37%
DSNY				20%	16%	23%
ECAO				20%	16%	26%
ENTG	31%	20%	38%	22%	20%	29%
ERCT	30%	24%	39%	22%	20%	28%
FRCC				20%	21%	28%
LILC				20%	17%	22%
MACE				21%	18%	26%
MACS				21%	19%	26%
MACW				20%	16%	26%
MANO				21%	18%	27%
MAPP	30%	17%	33%	21%	19%	30%
MECS				20%	16%	28%
NENG				20%	18%	28%
NWPE	35%	21%	37%	23%	17%	29%
NYC				20%	16%	27%
PNW	35%	21%	34%	23%	17%	28%
RMPA	36%	27%	44%	24%	24%	38%
SOU				20%	19%	29%
SPPN	31%	20%	37%	22%	20%	30%
SPPS	31%	20%	37%	22%	20%	28%
TVA				20%	19%	28%
UPNY				20%	16%	27%
VACA				20%	19%	28%
WUMS				21%	18%	30%
Average	34%	23%	40%	21%	19%	28%

Table 4.19. Reserve Margin Contribution and Average Capacity Factor by Wind Class and Model Region

Reserve Margin Contribution			
Model Region	Wind Class 6	Wind Class 5	Wind Class 4
AZNM	35%	31%	29%
CALI	37%	34%	31%
DSNY		39%	35%
ECAO		39%	36%
ENTG			32%
ERCT			31%
MACE			31%
MACS			31%
MACW			33%
MAPP		38%	32%
MECS		40%	36%
NENG	43%	39%	36%
NWPE	42%	37%	34%
PNW	44%	40%	36%
RMPA	42%	38%	34%
SOU	40%	37%	34%
SPPN			32%
SPPS			31%
TVA	41%	38%	35%
UPNY		41%	37%
VACA	41%	38%	34%
Average	41%	38%	33%
Averge Summer CF	41%	37%	34%
Average Winter CF	29%	27%	24%

Table 4.19 presents the average capacity factors (CFs) and contributions to reserve margin for wind plants in the EPA Base Case 2000. These assumptions apply to new wind plants. Assumptions on capacity factors and contributions to reserve margins for existing wind plants, were developed using historical data. Since the hourly generation profiles for wind plants vary by wind class, not by model region, only wind class average capacity factors are given, not region-specific capacity factors. The contributions to reserve margin vary by both wind class and model region. Thus, for each model region Table 4.19 includes separate values for each wind class.

4.5 Nuclear Units

4.5.1 Existing Nuclear Units

Population, Plant Location, Unit Configuration, Online and Retirement Year

The EPA Base Case 2000 includes model plants representing the 103 currently operating nuclear units in NEEDS. The population characteristics, plant location, and unit configuration data in NEEDS was obtained primarily from Form EIA 860. Technology type (i.e., pressurized water reactors and boiling water reactors) and design were taken from Nuclear Regulatory Commission (NRC) data. For nuclear units, NEEDS includes online and retirement dates, based on facility specific operating license data obtained from Cambridge Energy Research Associates' (CERA) and NRC databases. The online year is used to assign units to the vintage categories described below (i.e., pre- and post-1982). The retirement dates are used in EPA Base Case 2000 to model the 10-year lifetime extension and 20-year relicensing options also described below. Under the EPA Base Case 2000, Calvert Cliffs is considered to have relicensed. A list of the nuclear units in NEEDS and their key characteristics is presented in Appendix 4.4.

Capacity

Nuclear units are baseload power plants with high fixed (capital and fixed O&M) costs and low variable (fuel and variable O&M) costs. Due to their low VOM and fuel costs, nuclear units are run to the maximum extent possible, i.e., up to their availability. Consequently, as explained in section 3.5.2, a nuclear unit's capacity factor is equivalent to its availability. Thus, the EPA Base Case 2000 uses capacity factor assumptions to define the upper bound on generation from nuclear units. The average regional 1994-1999 nuclear generation values reported in Form EIA 759 were used to develop summer/winter capacity factors. These were coupled with the AEO 2000 nuclear capacity factor projection algorithm to develop the capacity factor assumptions in EPA Base Case 2000. The nuclear capacity factor projection algorithm is described below:

- For each reactor, the capacity factor over time is dependent on the age of the reactor.
- Capacity factors increase initially due to learning, and decrease in the later years due to aging.
- For individual reactors, vintage classifications (older and newer) are used.
- For the older vintage (start before 1982) nuclear power plants, the performance peaks at 25 years:
  - Before 25 years: Performance increases by 0.5 percentage point per year;
  - 25-30 years: Performance remains flat; and
  - 31-40 years: Performance decreases by 0.5 percentage points per year.
- For the newer vintage (start in or after 1982) nuclear power plants, the performance peaks at 30 years:
  - Before 30 years: Performance increases by 0.7 percentage points per year;
  - 30-34 years: Performance remains flat; and
  - 35-40 years: Performance decreases by 0.5 percentage points per year.

- The maximum capacity factor is assumed to be 84 percent.That is, any given reactor is not allowed to grow to a capacity factor higher than 84 percent. However, if a unit began with a capacity factor above 84 percent, it is allowed to retain that capacity factor. This explains the widespread occurrence in Table 4.20 of average regional capacity factors well above 84 percent.
  - When a reactor opts to renew its license, the capacity factor of that unit remains flat during the additional 20 years.

Table 4.20 presents the nuclear capacity factors resulting under EPA Base Case 2000. Since the capacity factors for individual plants vary in accordance with the assumptions discussed above and the plants within each region are unique, the average nuclear capacity factors displayed in this table vary by region and over time. Note that the capacity factors described in Table 4.20 below are outputs of the EPA Base Case 2000 and include changes in nuclear capacity from relicensing.

Table 4.20. Average Regional Nuclear Capacity Factors in EPA Base Case 2000

IPM Region/Year	2005	2010	2015	2020
AZNM	92.3%	92.3%	92.3%	92.3%
CALI	89.6%	89.6%	89.6%	89.2%
DSNY	65.5%	63.0%	NA	NA
ECAO	59.0%	58.4%	61.7%	66.0%
ENTG	90.2%	90.2%	90.2%	90.1%
ERCT	91.7%	91.7%	91.7%	91.7%
FRCC	87.1%	95.2%	95.2%	95.2%
LILC	NA	NA	NA	NA
MACE	83.8%	92.8%	92.8%	92.8%
MACS	93.1%	93.1%	93.1%	93.1%
MACW	90.5%	90.5%	90.5%	90.5%
MANO	78.6%	85.3%	86.4%	86.3%
MAPP	86.7%	85.6%	84.5%	84.5%
MECS	82.2%	83.1%	77.8%	77.8%
NENG	76.2%	86.4%	86.4%	86.4%
NWPE	NA	NA	NA	NA
NYC	NA	NA	NA	NA
PNW	72.9%	76.5%	78.7%	77.6%
RMPA	NA	NA	NA	NA
SOU	91.6%	91.3%	90.9%	90.7%
SPPN	93.1%	93.1%	93.1%	93.1%
SPPS	NA	NA	NA	NA
TVA	93.8%	93.8%	93.8%	93.8%
UPNY	85.9%	85.5%	85.5%	85.5%
VACA	90.4%	89.9%	89.4%	89.2%
WUMS	64.7%	62.2%	NA	NA
National Weighted Average	85.3%	87.1%	88.2%	89.4%

Cost and Performance

Unlike non-nuclear existing units discussed in section 4.2.7, emission rates are not used to characterize nuclear units, since there are no SO_2, NO_x, CO_2, or mercury emissions from nuclear units.

As with other generating resources, the EPA Base Case 2000 uses variable operation and maintenance (VOM) costs and fixed operation and maintenance (FOM) costs to characterize the cost of operating nuclear units. As indicated in Table 4.8, a VOM cost of 2.0 mills/kWh is assumed for nuclear units in EPA Base Case 2000. The VOM includes a 1 mill/kWh adder to account for the cost of nuclear waste disposal. The nuclear fuel cost assumptions in the EPA Base Case 2000 are presented in Section 8.5.

The EPA Base Case 2000 recognizes that FOM costs for nuclear units tend to vary with the size and age of the unit and the effectiveness of the unit operator. Hence, the 103 nuclear units in NEEDS were ranked from best to worst using an index that took into account their capacity factor (higher is better) and FOM costs (lower is better). The FOM costs were obtained from combined VOM-FOM cost data in a proprietary database of the Utility Data Institute (UDI). Plant specific 1993-1998 average O&M data were used. Based on its ranking, each unit was classified into one of three cost categories (low, mid and high). Then, within each IPM region, a weighted (by capacity) average FOM was derived for all units in the same category. The resulting region-specific low, mid, and high FOM values are used in EPA Base Case 2000 to obtain the operating cost of existing nuclear units. Based on this approach, FOM costs in EPA Base Case 2000 range from $42/kW-yr (in 1999 $) to $175/kW-yr (in 1999 $).

EPA Base Case 2000 offers the option of early retirement to nuclear units based on economic factors. The cost of decommissioning a nuclear unit is not taken into account in the retirement decision. Decommissioning costs are incurred whether a plant retires early or when its license expires and are recovered from a nuclear unit's rate base.

EPA Base Case 2000 also provides nuclear units with the option to undertake lifetime extensions and/or renew their operating license. Table 4.21 below summarizes the capital cost assumptions on lifetime extensions and nuclear re-licensing in the EPA Base Case 2000. Re-licensing and lifetime extensions do not involve any other incremental costs.

Table 4.21. Capital Cost Assumptions for Nuclear Relicensing and Lifetime Extension in EPA Base Case 2000

Option	Capital Cost (1999 $/kW)
10-Year Life Extension at Age 30	$150
20-Year Relicensing at Age 40	$324

The cost of the 10-Year Life Extension at Age 30 shown in Table 4.21 are adopted from AEO 2000. The following logic underlies the costs: For existing nuclear power plants to last the full 40-year license expiration period, certain age related capital investments need to be made. Steam generator replacement is one such investment. AEO 2000 assumes that plants that have not made such investments by the year 30 face a choice regarding retiring or making those investments. EPA Base Case 2000 recognizes that some existing nuclear power plants have already made such investments and do not need to exercise this option[11].

The cost of the 20-Year Relicensing at Age 40 shown in Table 4.21 is derived from comparable assumptions in AEO 2000. AEO 2000 assumes that an additional 175 $/kW investment would need to be made at year 40 and a 250 $/kW investment at year 50. The year 40 investment extends the life by an additional 10 years for a total of 50 years and the year 50 investment increases the life of the power plant to a total of 60 years. EPA Base Case 2000 merges the year 40 and the year 50 life extension options into a single year 40 life extension option, which extends the plant's life/license by 20 years. There are no lifetime extension options beyond the 20-year relicensing at age 40. If a plant reaches age 60, it is forced to retire. (Under the modeling time horizon in EPA Base Case 2000, this does not occur.)

4.5.2 Potential Nuclear Units

In modeling potential nuclear units, EPA Base Case 2000 adopts the cost and performance assumptions for Advanced Nuclear units found in the AEO 2001 Reference Case[12]. The resulting cost and

[11] The nuclear power plants that have already made some age related capital investments include Oconee, Pointbeach, Surry, Limerick, Davis-Besse, Waterford 3, Summer, Clinton, St. Lucie, Turkey Point, Millstone 2 & 3, Beaver Valley, Peach Bottom, Donald C. Cook, H.B. Robinson, Nine Mile Point 1, Palisades, Indianpoint 3, Oyster Creek, and Pilgrim. (Source: EIA)

[12] AEO 2001 includes three sets of nuclear assumptions: one set is used in the AEO 2001 Reference Case, the other two sets are used in two variants of the AEO 2001 Advanced Nuclear Cost Cases. Each of the sets of assumptions is designated as applying to "Advanced Nuclear" units. The cost and performance assumptions in the EPA Base Case 2000 are based on the AEO 2001 Reference Case assumptions for "Advanced Nuclear" units, not the Advanced Nuclear Cost Case assumptions for "Advanced Nuclear" units. EIA's *Assumptions for the Annual Energy Outlook 2001* (p.73) describes these assumptions as follows: "The cost and operating assumptions for the advanced

performance characteristics are shown above in Table 4.12. As is the case with other potential units, the capital cost of potential nuclear units includes the overnight capital cost from AEO and interest during construction, calculated based on the construction profile and the discount rate.

There are several points to note about the nuclear unit cost and performance asusmptions shown in Table 4.12. Costs and performance parameters are provided for three vintages of nuclear plants: 2005-2009, 2010-2014, and 2015 and after. Across all vintages, the heat rates, FOM and VOM remain the same. However, capital costs drop from $2,465 $/kW for units coming on line in the earliest vintage period (2005-2014) to $2,276 $/kW for units coming on line in the last vinatge peiod (2010-2014). Nuclear fuel costs for potential units are the same as for existing nuclear units and are presented in Section 8.5.

The capability to model new nuclear units and the cost and performance assumptions discussed here are built into EPA Base Case 2000. However, under the base case assumptions, no new nuclear capacity is added.

4.6 Repowering Options

The EPA Base Case 2000 provides coal steam units the option to repower to natural gas combined cycle and to IGCC. Oil-gas steam units are provided the option to repower to natural gas combined cycle units. These are the only repowering options provided in EPA Base Case 2000. Units elect to repower in the model only if it is economic to do so.

In EPA Base Case 2000, the cost and performance of a new combined cycle unit (described in Section 4.3.2 above) served as a starting point in developing the cost and performance assumptions for repowering to combined cycle. Similarly, the cost of a new IGCC was used to develop the cost for repowering coal to IGCC. Relative to new units, the cost of repowering is adjusted down to reflect the fact that there is a cost saving from not having to replace the steam turbine of the existing units and increased to reflect the demolition costs. Repowering, however, is slightly less expensive than a new unit but is also less efficient. Since the repowered unit is not optimized in design or space like a new unit, the heat rate of a repowered unit is assumed to be greater than the heat rate of new unit to reflect the loss in efficiency. For example, the assumed heat rate of 7260 Btu/kWh for a coal unit repowered to IGCC for 2010 and beyond is greater than the 6,968 Btu/kWh, the heat rate for a new IGCC over the same period as shown in Table 4.12 .

Table 4.22 summarizes the cost and performance assumptions on repowering used in EPA Base Case 2000. Table 4.7 above enumerates the repowering options built into EPA Base Case 2000. Tables A4.1.6, A4.1.7, A4.1.10, and A4.1.11 in Appendix 4.1 provide more detailed breakdowns of retirement options by IPM region, capacity category, heat rate category, and compliance zone. In addition, for the coal to IGCC repowering option, Appendix 4.1 provides a breakdown by coal supply region, burner type, particulate control type, and post-combustion control type.

nuclear technology represented in NEMS [Reference Case] are based on Westinghouse's advanced passive reactor design (AP600). It is one of three new designs that have received design certification from the Nuclear Regulatory Commission (NRC), a necessary step to new nuclear construction."

Table 4.22. Cost and Performance Assumptions for Repowering Options in EPA Base Case 2000

	Repower Coal to Coal IGCC	Repower Coal to Gas Combined Cycle	Repower Oil/Gas to Gas Combined Cycle
Size (MW)	428	400	400
First Year Available	2010	2005	2005
Lead Time(years)	4	3	3
Vintage #1 (years covered)	2010 and after	2005 and after	2005 and after
Availability	87.7%	90.4%	90.4%
Vintage #1			
Repowering Ratio	100%	100%	100%
Heat Rate (Btu/kWh)	7,260	6,606	6,606
Capital ($/kW)	1,282	477	477
Fixed O&M ($/kW-yr)	32.1	12.74	12.74
Variable O&M ($/MWh)	1.1	1.1	1.1

Appendix 4.1 Plant Aggregation Profile for EPA Base Case 2000

Table 4.7 gives a high level overview of the aggregation scheme employed in EPA Base Case 2000. A more detailed breakdown of the aggregation scheme is presented in the 13 tables in this appendix. The specific tables included in this appendix are listed below.

Table A4.1.1. Aggregation Profile in EPA Base Case 2000 — Existing Plants* by Model Region

	Coal Steam		Oil/Gas Steam		Combined Cycle		Turbine		IGCC		Nuclear		Hydro		Pumped Storage	
	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants
Totals	1,308	655	884	174	723	156	4676	227	3	3	103	47	3,894	31	139	18
By IPM Region																
NENG	18	14	51	19	55	14	204	16	0	0	5	4	568	2	8	2
UPNY	39	14	14	3	57	6	159	7	0	0	4	2	293	1	12	1
DSNY	4	2	12	2	11	3	21	2	0	0	2	2	105	1	4	1
NYC	0	0	19	4	14	4	97	4	0	0	0	0	0	0	0	0
LILC	0	0	0	0	3	3	15	1	0	0	0	0	0	0	0	0
MAPP	136	87	48	8	10	4	877	11	0	0	6	2	237	1	0	0
WUMS	58	29	9	3	2	1	76	9	0	0	3	2	165	1	0	0
MANO	85	48	31	6	13	4	359	14	0	0	12	5	38	2	2	1
SPPS	26	13	101	14	22	6	171	15	0	0	0	0	80	2	7	1
SPPN	43	29	34	10	3	1	522	14	0	0	1	1	19	2	5	1
ERCT	27	14	160	24	89	22	134	20	0	0	4	2	40	3	0	0
RMPA	37	26	13	4	25	7	97	9	0	0	0	0	101	1	5	1
NWPE	34	19	8	3	4	2	67	5	1	1	0	0	220	1	1	0
AZNM	28	17	31	6	41	11	51	8	0	0	3	1	45	1	6	1
PNW	4	3	1	1	29	6	25	4	0	0	1	1	603	1	5	1
CALI	17	6	94	13	103	11	325	10	0	0	4	1	455	1	30	1
ECAO	304	135	24	5	4	2	238	8	1	1	6	3	143	1	3	1
MECS	60	25	13	6	25	5	298	7	0	0	2	2	164	1	6	1
MACE	24	18	35	10	59	10	162	9	0	0	8	5	14	1	11	1
MACW	59	27	2	1	18	3	88	5	0	0	3	1	45	1	3	1
MACS	13	6	9	3	4	2	73	6	0	0	2	1	2	1	0	0
FRCC	27	15	72	10	55	9	225	9	1	1	5	2	6	1	0	0
VACA	122	53	6	3	41	7	225	10	0	0	16	4	241	1	22	1
TVA	59	17	2	1	0	0	59	5	0	0	5	1	131	1	4	1
SOU	71	31	26	7	15	6	85	13	0	0	6	2	164	1	5	1
ENTG	13	7	69	8	21	7	23	6	0	0	5	3	15	2	0	0

*IPM plants with total capacity of #0.5 MW were not included in EPA Base Case 2000.

Table A4.1.1(continued). Aggregation Profile in EPA Base Case 2000 — Existing Plants* by Model Region

	Biomass		Wind		Fuel Cells		Solar		Geothermal		Landfill Gas		Fossil Waste		Non-Fossil Waste	
	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants
Totals	112	23	91	8	2	0	21	2	197	2	7	3	7	6	116	30
By IPM Region																
NENG	28	2	11	1	0	0	0	0	0	0	2	1	0	0	26	3
UPNY	1	1	0	0	0	0	0	0	0	0	0	0	0	0	5	2
DSNY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2
NYC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LILC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1
MAPP	1	1	6	1	0	0	0	0	0	0	0	0	0	0	3	2
WUMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANO	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
SPPS	1	1	0	0	0	0	0	0	0	0	0	0	0	0	6	4
SPPN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ERCT	0	0	2	1	0	0	2	1	0	0	0	0	2	2	4	0
RMPA	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0
NWPE	0	0	5	0	0	0	0	0	54	1	0	0	1	1	1	1
AZNM	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
PNW	12	2	1	1	0	0	0	0	0	0	0	0	0	0	5	1
CALI	35	2	63	1	2	0	14	1	143	1	4	1	1	1	9	2
ECAO	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MECS	7	2	1	1	0	0	0	0	0	0	0	0	0	0	3	2
MACE	0	0	0	0	0	0	0	0	0	0	1	1	0	0	10	1
MACW	2	2	1	1	0	0	0	0	0	0	0	0	0	0	5	2
MACS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
FRCC	3	2	0	0	0	0	0	0	0	0	0	0	0	0	20	2
VACA	6	2	0	0	0	0	3	0	0	0	0	0	0	0	8	2
TVA	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOU	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ENTG	3	2	0	0	0	0	0	0	0	0	0	0	2	1	2	1

*IPM plants with total capacity of #0.5 MW were not included in EPA Base Case 2000.

Table A4.1.2. Aggregation Profile in EPA Base Case 2000 — Existing Plants* by Capacity and Heat Rate

By Capacity (MW)	Coal Steam		Oil/Gas Steam		Combined Cycle		Turbine	
	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants
<=25 MW	196	77	238	59	241	54	3,867	125
>25 MW and #100 MW	331	194	646	115	482	102	809	102
>100 MW	780	384						
By Heat Rate	**Coal Steam**		**Oil/Gas Steam**		**Combined Cycle**		**Turbine**	
	Units	**IPM model Plants**	**Units**	**IPM model Plants**	**Units**	**IPM model Plants**	**Units**	**IPM model Plants**
					Cat 1 # 7,000 Btu/kWh		Cat 1 # 9,200 Btu/kWh	
					7,000 < Cat 2 # 9,000		9,200 < Cat 2 # 12,000	
	Category 1 # 10,600 Btu/kWh				9,000 < Cat 3 # 10,500		12,000 < Cat 3 # 14,000	
	Category 2 > 10,600 Btu/kWh				Cat 4 > 10,500 Btu/kWh		Cat 4 > 14,000 Btu/kWh	
Category 1	1,023	477	634	123	100	31	114	34
Category 2	284	178	250	51	213	49	766	73
Category 3	-----	-----	-----	-----	254	45	469	52
Category 4	-----	-----	-----	-----	156	31	3,327	68

*IPM plants with total capacity of #0.5 MW were not included in EPA Base Case 2000.

Table A4.1.3. Aggregation Profile in EPA Base Case 2000 — Existing Plants* by Compliance Zones

	Coal Steam		Oil/Gas Steam		Combined Cycle		Turbine		IGCC		Nuclear		Hydro		Pumped Storage	
	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants
All fossil units in Sip Call States and D.C.	802	361	206	59	309	65	1,855	90	1	1	0	0	0	0	0	0
NH, VT, ME	7	7	11	5	3	1	71	4	0	0	0	0	0	0	0	0
MO, TX	86	50	206	41	104	28	430	45	0	0	0	0	0	0	0	0
All other fossil units	413	237	461	69	307	62	2,320	88	2	2	0	0	0	0	0	0
All non-fossil units	0	0	0	0	0	0	0	0	0	0	103	47	3,894	31	139	18

	Biomass		Wind		Fuel Cells		Solar		Geothermal		Landfill Gas		Fossil Waste		Non-Fossil Waste	
	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants	Units	IPM model Plants
All fossil units in Sip Call States and D.C.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
NH, VT, ME	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MO, TX	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0
All other fossil units	0	0	0	0	0	0	0	0	0	0	0	0	4	3	0	0
All non-fossil units	112	23	91	8	2	0	21	2	197	2	7	3	0	0	116	30

*IPM plants with total capacity of #0.5 MW were not included in EPA Base Case 2000.

Table A4.1.4. Aggregation Profile in EPA Base Case 2000 — Retrofit Plants by Model Region

	Coal To Scrubber Retrofit	Retrofit Coal to Scrubber + SCR	Retrofit Coal to Scrubber + SNCR	Retrofit Coal to Gas Reburn	Retrofit Coal to Gas Reburn + Scrubber	Retrofit Coal to Selective Catalytic Reduction (SCR)	Retrofit Coal to Selective Noncatalytic Reduction (SNCR)	Retrofit Coal to Activated Carbon Injection (ACI)	Retrofit Coal to ACI + SCR
Totals	461	884	896	137	96	357	617	845	346
By IPM Region									
NENG	11	10	10	0	0	3	7	13	3
UPNY	6	8	8	0	0	3	12	16	3
DSNY	2	4	4	0	0	2	2	2	2
NYC	0	0	0	0	0	0	0	0	0
LILC	0	0	0	0	0	0	0	0	0
MAPP	25	57	57	25	7	35	87	101	31
WUMS	16	32	32	15	8	8	29	34	8
MANO	44	85	89	9	5	30	47	69	34
SPPS	18	32	32	0	0	11	12	16	10
SPPN	14	29	29	9	4	14	29	41	9
ERCT	12	30	30	1	1	14	14	14	5
RMPA	4	8	8	7	1	13	26	21	4
NWPE	7	15	15	1	1	15	19	20	7
AZNM	2	4	4	0	0	17	17	17	2
PNW	2	5	5	1	0	2	3	3	2
CALI	0	0	0	0	0	0	5	6	0
ECAO	94	194	194	43	37	74	132	210	92
MECS	19	41	41	4	1	11	25	34	17
MACE	16	14	16	0	0	6	11	17	4
MACW	23	29	31	2	0	9	22	40	12
MACS	9	12	12	2	2	4	4	6	4
FRCC	12	25	25	2	4	8	11	19	11
VACA	50	93	97	8	13	31	50	57	25
TVA	24	46	46	2	3	16	16	35	23
SOU	39	87	87	4	6	25	31	46	32
ENTG	12	24	24	2	3	6	6	8	6

Table A4.1.4 (continued). Aggregation Profile in EPA Base Case 2000 — Retrofit Plants by Model Region

	Retrofit Coal to ACI + SNCR	Retrofit Coal to ACI + Scrubber	Retrofit Coal to ACI + Scrubber + SCR	Retrofit Coal to ACI + Scrubber + SNCR	Retrofit Coal to Biomass Cofiring	Retrofit Oil and Gas to SCR	Retrofit Oil and Gas to SNCR	Retrofit Nuclear -- 10 year extension at age 30	Retrofit Nuclear -- 20 year extension at age 40	Retrofit Nuclear - - 10 and 20 year extensions
Totals	647	838	133	135	0	186	186	30	16	30
By IPM Region										
NENG	6	9	0	0	0	27	27	2	2	2
UPNY	13	8	0	0	0	3	3	1	1	1
DSNY	2	2	0	0	0	2	2	1	1	1
NYC	0	0	0	0	0	4	4	0	0	0
LILC	0	0	0	0	0	0	0	0	0	0
MAPP	91	69	21	21	0	8	8	2	0	2
WUMS	34	32	0	0	0	3	3	1	1	1
MANO	54	83	15	15	0	6	6	4	1	4
SPPS	13	32	0	0	0	14	14	0	0	0
SPPN	26	28	3	3	0	10	10	1	0	1
ERCT	7	22	12	14	0	24	24	2	0	2
RMPA	17	12	0	0	0	4	4	0	0	0
NWPE	14	21	3	3	0	3	3	0	0	0
AZNM	3	6	0	0	0	6	6	1	0	1
PNW	3	2	1	1	0	1	1	1	0	1
CALI	6	0	0	0	0	13	13	1	0	1
ECAO	158	169	24	24	0	5	5	1	2	1
MECS	30	36	7	7	0	6	6	1	1	1
MACE	7	16	0	0	0	14	14	2	3	2
MACW	31	28	3	3	0	1	1	1	0	1
MACS	4	10	0	0	0	3	3	0	0	0
FRCC	17	23	3	3	0	10	10	1	1	1
VACA	44	94	3	3	0	3	3	2	2	2
TVA	23	43	5	5	0	1	1	1	0	1
SOU	38	73	21	21	0	7	7	2	0	2
ENTG	6	20	12	12	0	8	8	2	1	2

Table A4.1.5. Aggregation Profile in EPA Base Case 2000 — Retrofit Plants by Capacity, Heat Rate and Compliance Zone

	Coal To Scrubber Retrofit	Retrofit Coal to Scrubber+SCR	Retrofit Coal to Scrubber+SNCR	Retrofit Coal to Gas Reburn	Retrofit Coal to Gas Reburn + Scrubber	Retrofit Coal to Selective Catalytic Reduction (SCR)	Retrofit Coal to Selective Noncatalytic Reduction (SNCR)	Retrofit Coal to Activated Carbon Injection (ACI)	Retrofit Coal to ACI + SCR
By Capacity									
<= 25 MW	0	0	0	33	0	0	77	3	0
>25 MW and #100 MW	12	12	24	37	0	4	187	318	3
> 100 MW	449	872	872	67	96	353	353	524	343
By Heat Rate									
# 10,600 Btu/kWh	352	673	677	97	77	287	442	613	295
> 10,600 Btu/kWh	109	211	219	40	19	70	175	232	51
By Compliance Zone									
All fossil units in Sip Call States and D.C.	311	571	583	70	61	195	334	511	234
NH, VT, ME	2	0	0	0	0	0	3	6	0
MO, TX	36	76	76	14	8	32	49	59	17
All other fossil units	112	237	237	53	27	130	231	269	95
All non-fossil units	0	0	0	0	0	0	0	0	0

Table A4.1.5 (continued). Aggregation Profile in EPA Base Case 2000 — Retrofit Plants by Capacity, Heat Rate and Compliance Zone

	Retrofit Coal to ACI + SNCR	Retrofit Coal to ACI + Scrubber	Retrofit Coal to ACI + Scrubber + SCR	Retrofit Coal to ACI + Scrubber + SNCR	Retrofit Coal to Biomass Cofiring	Retrofit Oil and Gas to SCR	Retrofit Oil and Gas to SNCR	Retrofit Nuclear -- 10 year extension at age 30	Retrofit Nuclear -- 20 year extension at age 40	Retrofit Nuclear -- 10 and 20 year extensions
By Capacity										
# 25 MW	3	0	0	0		59	59			
>25 MW and #100 MW	284	24	0	0		127	127			
> 100 MW	360	814	133	135						
By Heat Rate										
# 10,600 Btu/kWh	463	619	112	112		129	129			
> 10,600 Btu/kWh	184	219	21	23		57	57			
By Compliance Zone										
All fossil units in Sip Call States and D.C.	394	523	66	66	0	69	69	0	0	0
NH, VT, ME	2	0	0	0	0	7	7	0	0	0
MO, TX	39	66	18	20	0	41	41	0	0	0
All other fossil units	212	249	49	49	0	69	69	0	0	0
All non-fossil units	0	0	0	0	0	0	0	30	16	30

Table A4.1.6. Aggregation Profile in EPA Base Case 2000 — Repowerings and Early Retirements by Model Region

	Repowerings			Early Retirements				
	Coal To CC repowering	O/G To CC repowering	Coal To IGCC repowering	Coal Early Retirement	O/G Early Retirement	CC Early Retirement	CT Early Retirement	Nuclear Early Retirement
Totals	539	174	539	655	174	83	190	47
By IPM Region								
NENG	14	19	14	14	19	7	14	4
UPNY	13	3	13	14	3	2	4	2
DSNY	2	2	2	2	2	1	2	2
NYC	0	4	0	0	4	2	3	0
LILC	0	0	0	0	0	1	1	0
MAPP	76	8	76	87	8	4	10	2
WUMS	27	3	27	29	3	1	9	2
MANO	41	6	41	48	6	3	13	5
SPPS	6	14	6	13	14	5	11	0
SPPN	26	10	26	29	10	1	14	1
ERCT	3	24	3	14	24	9	16	2
RMPA	24	4	24	26	4	3	7	0
NWPE	16	3	16	19	3	1	5	0
AZNM	15	6	15	17	6	7	7	1
PNW	1	1	1	3	1	3	4	1
CALI	6	13	6	6	13	6	6	1
ECAO	108	5	108	135	5	2	7	3
MECS	22	6	22	25	6	1	6	2
MACE	17	10	17	18	10	4	7	5
MACW	22	1	22	27	1	1	4	1
MACS	4	3	4	6	3	1	6	1
FRCC	13	10	13	15	10	6	7	2
VACA	50	3	50	53	3	5	8	4
TVA	13	1	13	17	1	0	5	1
SOU	19	7	19	31	7	4	10	2
ENTG	1	8	1	7	8	3	4	3

Table A4.1.7. Aggregation Profile in EPA Base Case 2000 —
Repowerings and Early Retirements by Capacity, Heat Rate and Compliance Zone

<table>
<tr><th></th><th colspan="3">Repowerings</th><th colspan="5">Early Retirements</th></tr>
<tr><th></th><th>Coal To CC repowering</th><th>O/G To CC repowering</th><th>Coal To IGCC repowering</th><th>Coal Early Retirement</th><th>O/G Early Retirement</th><th>CC Early Retirement</th><th>CT Early Retirement</th><th>Nuclear Early Retirement</th></tr>
<tr><td>By Capacity (MW)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td><= 25 MW</td><td>29</td><td>28</td><td>29</td><td>77</td><td>59</td><td>18</td><td></td><td></td></tr>
<tr><td>>25 MW and <=100 MW</td><td rowspan="2">510</td><td rowspan="2">146</td><td>119</td><td></td><td rowspan="2">115</td><td rowspan="2">65</td><td></td><td></td></tr>
<tr><td>> 100 MW</td><td>391</td><td>384</td><td></td><td></td></tr>
<tr><td>By Heat Rate</td><td colspan="2">Cat 1 <= 7,000 Btu/kWh</td><td>Category 1 <= 10,600 Btu/kWh</td><td colspan="2" rowspan="2">Category 1 <= 10,600 Btu/kWh</td><td>Cat 1 < = 7000 Btu/kWh</td><td>Cat 1 < = 9200 Btu/kWh</td><td></td></tr>
<tr><td></td><td colspan="2">7,000 < Cat 2 <= 9,000</td><td></td><td>7000 < Cat 2 <=9000 Btu/kWh</td><td colspan="2">9200 < Cat 2 <=12,000 Btu/kWh</td></tr>
<tr><td></td><td colspan="2">9,000 < Cat 3 <= 11,500</td><td>Category 2 > 10,600 Btu/kWh</td><td colspan="2" rowspan="2">Category 2 > 10,600 Btu/kWh</td><td>9000 < Cat 3 <=11,500 Btu/kWh</td><td colspan="2">12,000 < Cat 3 <= 14,000 Btu/kWh</td></tr>
<tr><td></td><td colspan="2">Cat 4 > 11,500 Btu/kWh</td><td></td><td>Cat 4 > 11,500 Btu/kWh</td><td>Cat 4 > 14,000 Btu/kWh</td><td></td></tr>
<tr><td>Category 1</td><td>539</td><td>174</td><td>539</td><td>655</td><td>174</td><td>83</td><td>190</td><td></td></tr>
<tr><td>Category 2</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>Category 3</td><td>0</td><td>0</td><td>-----</td><td>-----</td><td>-----</td><td>0</td><td>0</td><td></td></tr>
<tr><td>Category 4</td><td>0</td><td>0</td><td>-----</td><td>-----</td><td>-----</td><td>0</td><td>0</td><td></td></tr>
<tr><td>By Compliance Zone</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>All fossil units in Sip Call States and D.C.</td><td>305</td><td>59</td><td>305</td><td>361</td><td>59</td><td>31</td><td>76</td><td>0</td></tr>
<tr><td>NH, VT, ME</td><td>7</td><td>5</td><td>7</td><td>7</td><td>5</td><td>1</td><td>3</td><td>0</td></tr>
<tr><td>MO, TX</td><td>30</td><td>41</td><td>30</td><td>50</td><td>41</td><td>13</td><td>38</td><td>0</td></tr>
<tr><td>All other fossil units</td><td>197</td><td>69</td><td>197</td><td>237</td><td>69</td><td>38</td><td>73</td><td>0</td></tr>
<tr><td>All non-fossil units</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>47</td></tr>
</table>

Table A4.1.8. Aggregation Profile in EPA Base Case 2000 — New Plants by Model Region

	Conventional Pulverized Coal	IGCC	Combined Cycle	Combustion Turbine	Advanced Combustion Turbine	Advanced Nuclear	Biomass	Wind	Fuel Cells	Solar Photovoltaics	Solar Thermal	Geothermal	Landfill Gas
Totals	76	76	78	78	78	78	41	195	78	34	18	16	41
By IPM Region													
NENG	6	6	6	6	6	3	3	18	6	2	0	0	3
UPNY	2	2	2	2	2	3	1	6	2	1	0	0	1
DSNY	2	2	2	2	2	3	1	6	2	1	0	0	1
NYC	2	2	2	2	2	3	1	0	2	1	0	0	1
LILC	2	2	2	2	2	3	1	0	2	1	0	0	1
MAPP	6	6	6	6	6	3	3	18	6	2	2	0	3
WUMS	4	4	4	4	4	3	2	0	4	1	0	0	2
MANO	6	6	6	6	6	3	3	0	6	2	2	0	3
SPPS	4	4	4	4	4	3	2	6	4	2	2	0	2
SPPN	2	2	2	2	2	3	3	9	2	2	2	0	3
ERCT	2	2	2	2	2	3	1	3	2	1	1	0	1
RMPA	2	2	2	2	2	3	1	9	2	1	1	1	1
NWPE	2	2	2	2	2	3	1	9	2	1	1	5	1
AZNM	4	4	4	4	4	3	2	18	4	2	2	4	2
PNW	2	2	2	2	2	3	1	9	2	1	1	3	1
CALI	0	0	2	2	2	3	1	9	2	1	1	3	1
ECAO	2	2	2	2	2	3	1	6	2	1	0	0	1
MECS	2	2	2	2	2	3	1	6	2	1	0	0	1
MACE	2	2	2	2	2	3	1	3	2	1	0	0	1
MACW	2	2	2	2	2	3	1	3	2	1	0	0	1
MACS	2	2	2	2	2	3	1	3	2	1	0	0	1
FRCC	2	2	2	2	2	3	1	0	2	1	0	0	1
VACA	2	2	2	2	2	3	1	9	2	1	0	0	1
TVA	4	4	4	4	4	3	2	18	4	1	0	0	2
SOU	4	4	4	4	4	3	2	18	4	1	0	0	2
ENTG	6	6	6	6	6	3	3	9	6	3	3	0	3

Table A4.1.9. Aggregation Profile in EPA Base Case 2000 — New Plants by Compliance Zones

	Conventional Pulverized Coal	IGCC	Combined Cycle	Combustion Turbine	Advanced Combustion Turbine	Advanced Nuclear	Biomass	Wind	Fuel Cells	Solar Photovoltaics	Solar Thermal	Geothermal	Landfill Gas
All fossil units in SIP Call States and D.C.	34	34	34	34	34	0	0	0	34	0	0	0	0
NH, VT, ME	2	2	2	2	2	0	0	0	2	0	0	0	0
MO, TX	14	14	14	14	14	0	0	0	14	0	0	0	0
All other fossil units	26	26	28	28	28	0	1	0	28	0	0	0	0
All non-fossil units	0	0	0	0	0	78	40	195	0	34	18	16	41

Table A4.1.10. Aggregation Profile in EPA Base Case 2000 — Coal Units (Existing, Repowerings, Retirements) by Coal Demand Region

Region	Existing Coal Steam		Repowerings		Early Retirements
	Units	IPM model Plants	Coal To Combined Cycle repowering	Coal To IGCC repowering	Coal Early Retirement
Totals	1,308	655	539	539	655
By Coal Demand Region					
ALRL	18	8		4	8
AMMM	18	12		9	12
AMNR	16	10		10	10
CAIN	16	8		8	8
CARL	92	39		36	39
CC	20	13		13	13
CU	19	12		11	12
DALG	16	11		11	11
EIMR	26	20		19	20
FLBG	19	11		10	11
FLRL	8	4		3	4
GARL	39	13		9	13
GFBG	9	6		2	6
GFRL	34	21		7	21
IBBG	57	24		17	24
IIIR	75	33		25	33
IIIT	43	24		24	24
IMBG	48	28		21	28
MABG	4	2		1	2
MARL	12	7		6	7
MIBG	85	39		36	39
MNRL	46	24		20	24
MWRL	70	46		39	46
NAIN	24	14		10	14
NE	27	20		19	20
NIIR	21	8		8	8
NORL	58	24		22	24
NU	39	14		13	14
ORPB	79	34		21	34
PC	43	20		15	20
PE	38	23		23	23
PRB	15	11		7	11
TABG	31	12		11	12
TKIN	18	3		2	3
TXLG	17	7		1	7
VEPR	33	15		15	15
WIRL	36	19		17	19
WOMR	7	3		3	3
WONR	21	9		7	9
WYGR	11	4		4	4

Table A4.1.11. Aggregation Profile in EPA Base Case 2000 — Coal Units (Existing, Repowerings, Retirements) by Burner, Particulate Control, and Combustion Control Type

	Existing Coal Steam		Repowerings		Early Retirements
Region	**Units**	**IPM model Plants**	**Coal To Combined Cycle repowering**	**Coal To IGCC repowering**	**Coal Early Retirement**
By Burner Type					
Cyclone	85	63	53	53	63
Pulverized Coal	1,004	493	389	389	493
Circulating Fluidized Bed	9	8	8	8	8
Stoker	16	12	12	12	12
Other	194	79	77	77	79
By Particulate Control Type					
ESP-Cold side or Cold Side + PM Scrubber	763	365	286	286	365
ESP - Hot Side	187	103	81	81	103
Fabric Filter	112	64	57	57	64
ESP_Cold Side + Fabric Filter	4	2	0	0	2
ESP_Hot Side + Fabric Filter	2	2	2	2	2
PM Scrubber	0	0	0	0	0
No Control	240	119	113	113	119
By Post Combustion Control Type					
SCR	13	8	3	3	8
SNCR	20	18	17	17	18
Wet Scrubber	204	112	80	80	112
Dry Scrubber	32	27	23	23	27
SCR & Wet Scrubber	11	8	5	5	8
SCR & Dry Scrubber	0	0	0	0	0
SNCR & Wet Scrubber	3	3	3	3	3
SNCR & Dry Scrubber	1	1	1	1	1
Mercury Control	0	0	0	0	0
No Control	1,024	478	407	407	478

Table A4.1.12. Aggregation Profile in EPA Base Case 2000 — Coal Retrofits by Coal Demand Region

Region	Retrofits						
	Coal To Scrubber Retrofit	Retrofit Coal to Scrubber + SCR	Retrofit Coal to Scrubber + SNCR	Retrofit Coal to Gas Reburn	Retrofit Coal to Gas Reburn + Scrubber	Retrofit Coal to Selective Catalytic Reduction (SCR)	Retrofit Coal to Selective Noncatalytic Reduction (SNCR)
Totals	461	884	896	137	96	357	617
By Coal Demand Region							
ALRL	11	26	26	1	0	7	8
AMMM	2	5	5	1	0	10	12
AMNR	2	4	4	0	0	10	10
CAIN	8	16	16	2	2	4	8
CARL	38	75	77	7	11	25	38
CC	4	8	8	2	1	8	13
CU	2	4	4	2	0	7	12
DALG	2	4	4	2	1	6	11
EIMR	3	6	6	9	3	5	20
FLBG	12	25	25	2	4	6	9
FLRL	0	0	0	0	0	2	2
GARL	16	36	36	1	2	9	13
GFBG	12	25	25	2	4	6	6
GFRL	28	63	63	1	1	20	21
IBBG	24	50	50	6	10	23	24
IIIR	31	65	65	12	7	18	32
IIIT	7	12	14	5	1	9	24
IMBG	15	30	30	2	1	14	27
MABG	4	4	4	0	0	1	1
MARL	5	8	8	2	2	4	6
MIBG	25	53	53	12	7	14	39
MNRL	4	9	9	8	2	8	24
MWRL	29	58	58	14	7	25	45
NAIN	10	21	21	6	5	7	12
NE	21	22	22	0	0	7	11
NIIR	16	30	32	2	4	8	8
NORL	11	23	23	6	2	7	24
NU	6	8	8	0	0	3	12
ORPB	31	63	63	12	12	24	33
PC	12	11	13	0	0	5	16
PE	17	22	22	2	0	8	17
PRB	2	4	4	2	1	9	11
TABG	14	24	24	1	2	10	11
TKIN	6	13	13	0	0	3	3
TXLG	2	6	6	0	0	7	7
VEPR	14	20	24	1	2	7	13
WIRL	11	22	22	11	2	6	19
WOMR	1	2	2	0	0	1	3
WONR	2	5	5	1	0	2	8
WYGR	1	2	2	0	0	2	4

Table A4.1.12 (continued). Aggregation Profile in EPA Base Case 2000 — Coal Retrofits by Coal Demand Region

Region	Retrofits						
	Retrofit Coal to Activated Carbon Injection (ACI)	Retrofit Coal to ACI + SCR	Retrofit Coal to ACI + SNCR	Retrofit Coal to ACI+Scrubber	Retrofit Coal to ACI + Scrubber + SCR	Retrofit Coal to ACI+Scrubber+ SNCR	Retrofit Coal to Biomass Cofiring
Totals	845	346	647	838	133	135	0
By Coal Demand Region							
ALRL	13	11	13	17	6	6	
AMMM	10	2	2	6	3	3	
AMNR	10	2	4	6	0	0	
CAIN	7	4	7	16	0	0	
CARL	43	20	35	74	3	3	
CC	11	4	9	12	0	0	
CU	14	2	11	6	0	0	
DALG	12	4	9	2	0	0	
EIMR	28	3	24	7	0	0	
FLBG	17	11	17	23	3	3	
FLRL	2	0	0	0	0	0	
GARL	12	8	10	32	12	12	
GFBG	13	13	13	24	3	3	
GFRL	26	16	18	56	21	21	
IBBG	43	23	26	47	5	5	
IIIR	51	30	46	56	21	21	
IIIT	36	8	28	13	0	0	
IMBG	40	13	31	33	12	12	
MABG	2	1	1	4	0	0	
MARL	8	3	5	6	0	0	
MIBG	56	20	52	50	7	7	
MNRL	21	5	16	10	3	3	
MWRL	62	21	48	63	12	12	
NAIN	15	8	13	17	3	3	
NE	19	7	10	19	0	0	
NIIR	8	8	8	32	0	0	
NORL	35	11	29	17	3	3	
NU	16	3	13	8	0	0	
ORPB	66	35	46	53	9	9	
PC	30	6	18	12	3	3	
PE	27	7	18	20	0	0	
PRB	11	2	6	6	0	0	
TABG	25	12	14	24	0	0	
TKIN	7	7	7	12	3	3	
TXLG	7	0	2	2	0	2	
VEPR	14	6	11	24	0	0	
WIRL	12	6	12	23	0	0	
WOMR	4	1	4	1	0	0	
WONR	9	2	9	2	1	1	
WYGR	3	1	2	3	0	0	

Table A4.1.13. Aggregation Profile in EPA Base Case 2000 — Coal Retrofits by Burner, Particulate Control, and Combustion Control Type

Subcategories	Retrofits						
	Coal To Scrubber Retrofit	Retrofit Coal to Scrubber + SCR	Retrofit Coal to Scrubber + SNCR	Retrofit Coal to Gas Reburn	Retrofit Coal to Gas Reburn + Scrubber	Retrofit Coal to Selective Catalytic Reduction (SCR)	Retrofit Coal to Selective Noncatalytic Reduction (SNCR)
By Burner Type							
Cyclone	62	108	110	38	38	39	56
Pulverized Coal	379	737	745	78	56	303	465
Circulating Fluidized Bed	0	0	0	1	0	3	8
Stoker	0	0	0	10	0	0	12
Other	20	39	41	10	2	12	76
By Particulate Control Type							
ESP-Cold side or Cold Side + PM Scrubber	328	620	626	82	76	223	333
ESP - Hot Side	89	173	177	19	15	67	100
Fabric Filter	22	46	46	10	3	37	61
ESP_Cold Side + Fabric Filter	2	6	6	0	0	2	2
ESP_Hot Side + Fabric Filter	0	0	0	0	0	1	2
PM Scrubber	0	0	0	0	0	0	0
No Control	20	39	41	26	2	27	119
By Post Combustion Control Type							
SCR	14	0	0	0	0	0	0
SNCR	25	0	0	0	0	0	0
Wet Scrubber	0	0	0	0	0	93	112
Dry Scrubber	0	0	0	0	0	17	27
SCR & Wet Scrubber	0	0	0	0	0	0	0
SCR & Dry Scrubber	0	0	0	0	0	0	0
SNCR & Wet Scrubber	0	0	0	0	0	0	0
SNCR & Dry Scrubber	0	0	0	0	0	0	0
Mercury Control	0	0	0	0	0	0	0
No Control	422	884	896	137	96	247	478

Table A4.1.13 (continued). Aggregation Profile in EPA Base Case 2000 — Coal Retrofits by Burner, Particulate Control, and Combustion Control Type

Subcategories	Retrofits					
	Retrofit Coal to Activated Carbon Injection (ACI)	Retrofit Coal to ACI + SCR	Retrofit Coal to ACI + SNCR	Retrofit Coal to ACI + Scrubber	Retrofit Coal to ACI + Scrubber + SCR	Retrofit Coal to ACI + Scrubber + SNCR	Retrofit Coal to Biomass Cofiring
By Burner Type							
Cyclone	97	45	72	102	17	17	
Pulverized Coal	656	285	500	696	113	115	
Circulating Fluidized Bed	7	0	1	0	0	0	
Stoker	11	0	11	0	0	0	
Other	74	16	63	40	3	3	
By Particulate Control Type							
ESP-Cold side or Cold Side + PM Scrubber	526	244	411	574	97	97	
ESP - Hot Side	136	65	107	174	27	27	
Fabric Filter	75	21	53	48	6	6	
ESP_Cold Side + Fabric Filter	2	0	2	2	0	2	
ESP_Hot Side + Fabric Filter	3	0	1	0	0	0	
PM Scrubber	0	0	0	0	0	0	
No Control	103	16	73	40	3	3	
By Post Combustion Control Type							
SCR	11	0	0	0	0	0	
SNCR	21	0	0	0	0	0	
Wet Scrubber	164	0	0	0	0	0	
Dry Scrubber	35	5	35	0	0	0	
SCR & Wet Scrubber	0	0	0	0	0	0	
SCR & Dry Scrubber	0	0	0	0	0	0	
SNCR & Wet Scrubber	0	0	0	0	0	0	
SNCR & Dry Scrubber	2	0	0	0	0	0	
Mercury Control	0	0	0	0	0	0	
No Control	612	341	612	838	133	135	

Appendix 4.2 Representative Wind and Solar Generation Profiles in EPA Base Case 2000

Table A4.2.1. Illustrative* Hourly Generation Profile from Wind (kWh of Generation per MW of Electricity)

	Wind Class		
	6	5	4
Winter Hour 1	355	325	296
Winter Hour 2	355	325	296
Winter Hour 3	355	325	296
Winter Hour 4	355	325	296
Winter Hour 5	355	325	296
Winter Hour 6	365	335	304
Winter Hour 7	365	335	304
Winter Hour 8	510	468	425
Winter Hour 9	510	468	425
Winter Hour 10	510	468	425
Winter Hour 11	510	468	425
Winter Hour 12	510	468	425
Winter Hour 13	510	468	425
Winter Hour 14	510	468	425
Winter Hour 15	510	468	425
Winter Hour 16	510	468	425
Winter Hour 17	510	468	425
Winter Hour 18	510	468	425
Winter Hour 19	365	335	304
Winter Hour 20	365	335	304
Winter Hour 21	365	335	304
Winter Hour 22	365	335	304
Winter Hour 23	365	335	304
Winter Hour 24	365	335	304
Winter Average	430	394	358

	Wind Class		
	6	5	4
Summer Hour 1	192	176	160
Summer Hour 2	192	176	160
Summer Hour 3	192	176	160
Summer Hour 4	192	176	160
Summer Hour 5	192	176	160
Summer Hour 6	220	202	184
Summer Hour 7	220	202	184
Summer Hour 8	419	384	349
Summer Hour 9	419	384	349
Summer Hour 10	419	384	349
Summer Hour 11	419	384	349
Summer Hour 12	419	384	349
Summer Hour 13	419	384	349
Summer Hour 14	419	384	349
Summer Hour 15	419	384	349
Summer Hour 16	419	384	349
Summer Hour 17	419	384	349
Summer Hour 18	419	384	349
Summer Hour 19	220	202	184
Summer Hour 20	220	202	184
Summer Hour 21	220	202	184
Summer Hour 22	220	202	184
Summer Hour 23	220	202	184
Summer Hour 24	220	202	184
Summer Average	306	280	255

Table A4.2.2. Illustrative* Hourly Generation Profile From Solar Thermal and Solar Photovoltaic (kWh of Generation per MW of Electricity)

	Solar Thermal	Solar Photovoltaic
Winter Hour 1	2	0
Winter Hour 2	2	0
Winter Hour 3	2	0
Winter Hour 4	2	0
Winter Hour 5	2	0
Winter Hour 6	441	422
Winter Hour 7	441	422
Winter Hour 8	441	422
Winter Hour 9	441	422
Winter Hour 10	441	422
Winter Hour 11	441	422
Winter Hour 12	441	422
Winter Hour 13	441	422
Winter Hour 14	441	422
Winter Hour 15	441	422
Winter Hour 16	278	225
Winter Hour 17	125	20
Winter Hour 18	125	20
Winter Hour 19	125	20
Winter Hour 20	125	20
Winter Hour 21	125	20
Winter Hour 22	125	20
Winter Hour 23	125	20
Winter Hour 24	125	20
Winter Average	237	192

	Solar Thermal	Solar Photovoltaic
Summer Hour 1	19	0
Summer Hour 2	19	0
Summer Hour 3	19	0
Summer Hour 4	19	0
Summer Hour 5	19	0
Summer Hour 6	19	0
Summer Hour 7	622	510
Summer Hour 8	622	510
Summer Hour 9	622	510
Summer Hour 10	622	510
Summer Hour 11	622	510
Summer Hour 12	622	510
Summer Hour 13	622	510
Summer Hour 14	622	510
Summer Hour 15	622	510
Summer Hour 16	622	510
Summer Hour 17	622	510
Summer Hour 18	622	510
Summer Hour 19	310	15
Summer Hour 20	310	15
Summer Hour 21	310	15
Summer Hour 22	310	15
Summer Hour 23	310	15
Summer Hour 24	310	15
Summer Average	393	259

* Based on model region NWPE

Appendix 4.3 Geothermal Cost and Performance Options in EPA Base Case 2000

Table A4.3.1. Geothermal Options Included in EPA Base Case 2000

Model Region	Potential Capacity (MW)	Capital Cost (1999 $/kW)	FOM (1999 $/kW-Yr)
AZNM	625	2,446	86
AZNM	570	3,034	109
CALI	4,398	2,007	105
CALI	1,453	2,539	142
CALI	2,493	3,159	128
NWPE	375	1,719	73
NWPE	375	1,800	62
NWPE	561	2,487	109
NWPE	725	2,772	100
NWPE	125	3,319	119
PNW	1,850	1,973	66
PNW	563	2,488	109
PNW	1,388	3,196	121
RMPA	1,675	5,750	211

Appendix 4.4 Existing Nuclear Units in NEEDS

Table A4.4.1. Key Characteristic of Existing Nuclear Units in NEEDS

Plant Name	ORIS Code	Unit ID	Region Name	State Name	On Line Year	Capacity MW	Util Heat Rate	Cost Category
Browns Ferry Nuclear	46	2N	TVA	Alabama	1975	1,065	10,430	High
Browns Ferry Nuclear	46	3N	TVA	Alabama	1977	1,118	10,430	High
Clinton Nuclear	204	RPVN	MANO	Illinois	1987	930	10,029	Low
Wolf Creek Nuclear	210	WC1RN	SPPN	Kansas	1985	1,167	9,762	Mid
San Onofre Nuclear	360	2N	CALI	California	1983	1,070	9,887	Mid
San Onofre Nuclear	360	3N	CALI	California	1984	1,080	9,887	Mid
Wnp-2 Nuclear	371	1N	PNW	Washington	1984	1,107	10,064	Mid
Millstone	566	CE2N	NENG	Connecticut	1975	871	10,152	Low
Millstone	566	WE3N	NENG	Connecticut	1986	1,140	9,963	Low
Turkey Point	621	PTP3N	FRCC	Florida	1972	666	11,023	Mid
Turkey Point	621	PTP4N	FRCC	Florida	1973	666	11,015	Mid
Crystal River	628	3N	FRCC	Florida	1977	812	10,670	Low
Vogtle Nuclear	649	UT1N	SOU	Georgia	1987	1,164	10,873	High
Vogtle Nuclear	649	UT2N	SOU	Georgia	1989	1,164	10,873	High
Dresden Nuclear	869	2N	MANO	Illinois	1970	772	11,139	Low
Dresden Nuclear	869	3N	MANO	Illinois	1971	773	11,113	Low
Quad Cities Nuclear	880	1N	MANO	Illinois	1972	769	10,946	Low
Quad Cities Nuclear	880	2N	MANO	Illinois	1972	769	10,967	Low
Duane Arnold Nuclear	1060	1	MAPP	Iowa	1975	520	10,888	Mid
Pilgrim Nuclear	1590	RPVN	NENG	Massachusetts	1972	669	10,177	Low
Palisades Nuclear	1715	1	MECS	Michigan	1972	760	10,367	Mid
Fermi Nuclear	1729	B21N	MECS	Michigan	1988	1,100	12,868	Low
Monticello Nuclear	1922	1	MAPP	Minnesota	1996	578	10,452	Mid
Prairie Island Nuclear	1925	1	MAPP	Minnesota	1974	526	10,746	Mid
Prairie Island Nuclear	1925	2	MAPP	Minnesota	1997	526	10,770	Mid
Fort Calhoun Nuclear	2289	1N	MAPP	Nebraska	1973	476	10,643	Low
Oyster Creek Nuclear	2388	OC1N	MACE	New Jersey	1969	619	10,740	Low
Salem Nuclear	2410	1N	MACE	New Jersey	1977	1,106	10,782	Low
Salem Nuclear	2410	2N	MACE	New Jersey	1981	1,106	10,687	Low
Indian Point Nuclear	2497	2N	DSNY	New York	1973	931	10,117	Low
Nine Mile Point Nuclear	2589	1N	UPNY	New York	1969	619	10,740	Mid
Nine Mile Point Nuclear	2589	2N	UPNY	New York	1988	1,095	10,740	Mid
Peach Bottom Nuclear	3166	2N	MACE	Pennsylvania	1974	1,093	10,436	Mid
Peach Bottom Nuclear	3166	3N	MACE	Pennsylvania	1974	1,035	10,545	High
H B Robinson	3251	2N	VACA	South Carolina	1971	683	10,163	High
Oconee Nuclear	3265	1N	VACA	South Carolina	1973	846	10,410	Mid
Oconee Nuclear	3265	2N	VACA	South Carolina	1974	846	10,315	Mid
Oconee Nuclear	3265	3N	VACA	South Carolina	1974	846	10,350	Mid
Vermont Yankee Nuclear	3751	1N	NENG	Vermont	1972	496	10,123	Low
Surry Nuclear	3806	1N	VACA	Virginia	1972	801	10,068	High
Surry Nuclear	3806	2N	VACA	Virginia	1973	801	10,068	High
Point Beach Nuclear	4046	1N	WUMS	Wisconsin	1970	493	10,400	Low
Point Beach Nuclear	4046	2N	WUMS	Wisconsin	1972	441	10,505	Low
Waterford #3 Nuclear	4270	W3-1N	ENTG	Louisiana	1985	1,075	10,539	Mid
Donald C Cook Nuclear	6000	1N	ECAO	Michigan	1975	1,000	10,721	Low
Donald C Cook Nuclear	6000	2N	ECAO	Michigan	1978	1,060	10,686	Low
Joseph M Farley Nuclear	6001	FNP-1N	SOU	Alabama	1977	815	11,000	Mid
Joseph M Farley Nuclear	6001	FNP-2N	SOU	Alabama	1981	825	11,000	Mid
Palo Verde Nuclear	6008	1N	AZNM	Arizona	1986	1,270	10,635	High
Palo Verde Nuclear	6008	2N	AZNM	Arizona	1986	1,270	10,499	High
Palo Verde Nuclear	6008	3N	AZNM	Arizona	1988	1,270	10,439	High
Calvert Cliffs Nuclear	6011	1N	MACS	Maryland	1975	835	10,857	Mid
Calvert Cliffs Nuclear	6011	2N	MACS	Maryland	1977	840	10,878	Mid
Brunswick Nuclear	6014	1N	VACA	North Carolina	1977	767	10,017	High
Brunswick Nuclear	6014	2N	VACA	North Carolina	1975	754	10,469	High
Harris Nuclear	6015	1N	VACA	North Carolina	1987	860	10,123	High
Perry Nuclear	6020	1N	ECAO	Ohio	1987	1,169	10,264	Mid
Braidwood Nuclear	6022	1N	MANO	Illinois	1988	1,090	10,295	Mid

Table A4.4.1. Key Characteristic of Existing Nuclear Units in NEEDS

Plant Name	ORIS Code	Unit ID	Region Name	State Name	On Line Year	Capacity MW	Util Heat Rate	Cost Category
Braidwood Nuclear	6022	2N	MANO	Illinois	1988	1,090	10,295	High
Byron Nuclear	6023	1N	MANO	Illinois	1985	1,120	10,399	Mid
Byron Nuclear	6023	2N	MANO	Illinois	1987	1,120	10,191	High
La Salle County Nuclear	6026	1N	MANO	Illinois	1984	1,048	10,585	Low
La Salle County Nuclear	6026	2N	MANO	Illinois	1984	1,048	10,716	Low
Catawba Nuclear	6036	1N	VACA	South Carolina	1985	1,129	10,084	Mid
Catawba Nuclear	6036	2N	VACA	South Carolina	1986	1,129	10,140	High
Mcguire Nuclear	6038	1N	VACA	North Carolina	1981	1,129	10,474	Mid
Mcguire Nuclear	6038	2N	VACA	North Carolina	1984	1,129	10,238	Mid
Beaver Valley Nuclear	6040	1ABC	ECAO	Pennsylvania	1976	810	10,850	Low
Beaver Valley Nuclear	6040	2ABC	ECAO	Pennsylvania	1987	820	10,560	Low
St Lucie Nuclear	6045	PSL1N	FRCC	Florida	1976	839	10,923	Mid
St Lucie Nuclear	6045	PSL2N	FRCC	Florida	1983	839	11,103	Mid
Edwin I Hatch	6051	1N	SOU	Georgia	1975	759	10,893	Mid
Edwin I Hatch	6051	2N	SOU	Georgia	1979	813	10,983	Mid
Grand Gulf Nuclear	6072	1BN	ENTG	Mississippi	1985	1,173	11,151	High
Diablo Canyon Nuclear	6099	1N	CALI	California	1985	1,073	10,455	Mid
Diablo Canyon Nuclear	6099	2N	CALI	California	1986	1,087	10,503	Mid
Susquehanna Nuclear	6103	1N	MACW	Pennsylvania	1983	1,090	10,505	Mid
Susquehanna Nuclear	6103	2N	MACW	Pennsylvania	1985	1,094	10,457	Mid
Limerick Nuclear	6105	1N	MACE	Pennsylvania	1986	1,055	10,614	High
Limerick Nuclear	6105	2N	MACE	Pennsylvania	1990	1,115	10,507	High
James A Fitzpatrick	6110	1N	UPNY	New York	1975	820	9,964	Mid
Seabrook Nuclear	6115	RX1N	NENG	New Hampshire	1990	1,156	10,152	Mid
Hope Creek Nuclear	6118	1N	MACE	New Jersey	1986	1,031	10,822	Mid
Ginna	6122	001N	UPNY	New York	1970	470	10,490	Mid
Summer Nuclear	6127	XRE1N	VACA	South Carolina	1984	948	10,740	High
Comanche Peak Nuclear	6145	1N	ERCT	Texas	1990	1,150	10,571	Mid
Comanche Peak Nuclear	6145	2N	ERCT	Texas	1993	1,150	10,621	Mid
Davis-Besse	6149	1N	ECAO	Ohio	1977	873	10,158	Mid
Sequoyah Nuclear	6152	1N	TVA	Tennessee	1981	1,111	10,172	High
Sequoyah Nuclear	6152	2N	TVA	Tennessee	1982	1,106	10,172	High
Callaway Nuclear	6153	1N	MANO	Missouri	1984	1,125	10,460	High
North Anna Nuclear	6168	1N	VACA	Virginia	1978	893	10,050	High
North Anna Nuclear	6168	2N	VACA	Virginia	1980	897	10,050	High
South Texas Nuclear	6251	STP1N	ERCT	Texas	1988	1,251	10,492	High
South Texas Nuclear	6251	STP2N	ERCT	Texas	1989	1,251	10,148	High
River Bend Nuclear	6462	1N	ENTG	Louisiana	1986	936	11,414	Mid
Watts Bar Nuclear	7722	1N	TVA	Tennessee	1996	1,118	10,740	High
Three Mile Island Nuclear	8011	1N	MACW	Pennsylvania	1974	786	11,148	Mid
Kewaunee Nuclear	8024	1N	WUMS	Wisconsin	1974	519	11,004	Low
Cooper Nuclear	8036	1N	MAPP	Nebraska	1974	778	10,725	Mid
Arkansas Nuclear One	8055	1N	ENTG	Arkansas	1974	836	11,080	Mid
Arkansas Nuclear One	8055	2N	ENTG	Arkansas	1980	858	11,445	High
Indian Point 3 Nuclear	8907	1N	DSNY	New York	1976	970	10,327	Low